A HISTORY OF BOTANY

J Reynolds Green

A HISTORY *of* BOTANY

IN THE UNITED KINGDOM FROM THE EARLIEST TIMES TO THE END OF THE 19TH CENTURY

BY

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TO

R. J. HARVEY GIBSON

IN MEMORY OF A NEVER-BROKEN FRIENDSHIP

PREFACE

THE circumstances under which this volume is published appear to justify a preface of a somewhat unusual kind. The book represents the research of Dr. Reynolds Green during the last years of his life, and he was working at it almost up to the hour of his death. Had it not been for the constant assistance of his friend and colleague, Professor Harvey Gibson of the University of Liverpool, it would have been impossible for him to have completed it, and it is in accordance with what I know would have been his wish that I have ventured to dedicate this, his latest work, to one who was his most intimate and valued friend for very many years.

Nor must I forget another of his nearest friends, Mr. J. M. Dent, to whom the publication of the book is due and on whom an unusual burden, so cheerfully accepted, was laid by my brother's long illness.

It may not be inappropriate that a few lines should be added about the life and works of the Author himself.

Dr. Reynolds Green was born at Stowmarket in 1848 and was educated at a private school at St. Ives; ultimately he became associated with his father in business and only retired to devote himself to scientific pursuits in 1881. In the meantime he had taken his bachelor's degree in Science at London. In the same year, 1881, he went up to Trinity College, Cambridge, was elected to a Major Scholarship in 1882 and was placed in the First Class of Part 1 of the Natural Science Tripos in 1883 and in the First Class of Part 2 in 1884 (Botany and Physiology). He took his M.A. in 1888 and his Doctorate in 1894. From 1885 to 1887 he held the post of Senior Demonstrator of Physiology in the University under the late Sir Michael Foster, was Rolleston Prizeman of the University of Oxford in 1890, and President of Section K (Botany) of the British Association in 1902. From 1887 to 1907 he was Professor of Botany to the Pharmaceutical Society of Great Britain, while in 1902 he was elected a Fellow and Lecturer at Downing College, Cambridge. From 1907 to the present year he held the Hartley Lectureship in Plant Physiology in the University of Liverpool.

In addition to many original papers contributed to the Royal

Society (to which he was elected in 1895) he published the following works:—*A Manual of Botany* (1895), *The Soluble Ferments and Fermentation* (1899, translated into German in 1901), *Introduction to Vegetable Physiology* (1900), *Primer of Botany* (1910), and *A History of Botany from* 1860 *to* 1900 (1910).

Of the value of his scientific work I am not qualified to speak, but I wish to place on record the conviction of all who knew him well that in his private life he uniformly displayed those qualities of patience, persistence, open-mindedness, and modesty, which are the best qualifications for any seeker after truth in every field of learning.

G. E. GREEN.

GONVILLE AND CAIUS COLLEGE,
CAMBRIDGE, *June* 1914.

APPENDIX TO PREFACE

IN the Autumn of 1913 owing to serious illness Dr. Reynolds Green found himself unable to correct the proofs of the present work and I undertook to aid him in the task so far as it lay in my power to do so. Fortunately, save for the Preface and Index, the MS. had been completed, while the Table of Contents and Chronological Summary had been sketched out.

In the early summer of the present year Dr. Green's health had improved sufficiently to warrant his attempting to read over the "final revise." This task he had just begun when to the grief of his many friends and the deep regret of all his fellow botanists he succumbed to a second stroke following on an operation.

As I had been familiar with the work from its first inception, his brother, Mr. G. E. Green of Caius College, Cambridge, asked me to undertake the melancholy duty of preparing the proofs for the press. In doing so I have incorporated such slight emendations or alterations as I found the author had made in pencil on the final revise, but otherwise, beyond purely typographical corrections, I have not altered the text in any way. The Table of Contents and the Chronological Summary have been finished on the lines sketched out by the author and a Name Index added. The Index is the work of Miss M. Knight, M.Sc., who has during the past two years acted as Dr. Green's Assistant in the course of instruction he was in the habit of giving annually as Lecturer in Plant Physiology in the University of Liverpool.

The work ends somewhat abruptly, but a pencil note following the sentence referring to the Duke of Bedford's experimental fruit farm on p. 623 shows that the author meant to add a "sketch of the position in 1900," but no memoranda have been left to indicate how he proposed to deal with the subject.

To this explanation of my incidental connection with this valuable contribution to the History of Botany, I would desire to add an expression of my admiration for the character and attainments of one who must be accorded a place among our most distinguished plant physiologists and of my gratitude for constant help and advice given during an intimate comradeship lasting for more than a quarter of a century. What Derham said of John Ray may with equal appropriateness be said of Reynolds Green:—"In his dealings, no man more strictly just; in his conversation, no man more humble, courteous, and affable."

R. J. HARVEY GIBSON.

University of Liverpool,
June 1914.

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EARLY BOTANY AND THE HERBALISTS

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BOOK I

CHAPTER I

THE EARLY TIMES

WHILE the foundations of an interest in, and a knowledge of, plants are lost in antiquity, we may fairly assume them to have been co-extensive with the power of man to bend to his own service the material things with which he has found himself surrounded. No doubt the great problems of human need were in some way the cause of the attention that was first given to the vegetable world. The question of food supply and the part which the herb of the field might play in providing its answer must have impressed primitive man, and have led, at some prehistoric date, to the first actual though unexpressed classification of plants into the wholesome and the deleterious. We may picture to ourselves a probable course of development of knowledge in both these directions, rudimentary as its beginnings must have been.

The earliest actual information which we possess is furnished by the ancient Greek writers, but it is very incomplete, even fragmentary, and leaves us to make our own sketches of the probable course of development from the earliest beginnings to the condition of knowledge which their works reveal.

In the hot regions of the Mediterranean Sea, vegetable food was for the most part sought in the succulent fruits and the buds and leaves, the cereal grains and the pulse-like seeds, the subterranean parts of plants being in much less demand. On the other hand, these organs were soon found to furnish crude medicaments which, after a time of experiment, led to the observation or discovery that, though they might be deleterious if used in large quantities, they were certainly beneficial under more careful administration. Hence sprang up a recognition of a crude *Materia Medica.*

We get in this way two lines of development of knowledge suggested: the first more general, and leading to the less specialised study of plants, the second restricted to the necessities of the healing art.

This line of progress was, however, not entirely in the direction of the general good. So far as it helped to bring into existence the cult of the physician, it was altogether admirable. But with the crude *Materia Medica* there arose a class of person who, realising the power to be gained by playing on the superstitions of the common people, built up an altogether disproportionate reverence for not only the medicament itself, but for those who administered it, whereby they were able gradually to establish a kind of authority over the rest of the people, and to establish in fact the cult of the "medicine man."

We find evidence of the forerunners of the promoters of this class in the Rhizotomi of Greece—persons who were originally only collectors of old roots and other underground parts of plants, which they sold as remedies for various disorders. We can trace too the early steps of the development of the superstitious idea. Many plants from their deleterious and perhaps offensive character demanded particular precautions in handling and collecting them—precautions which gradually became more and more elaborate and were after a time associated with ideas of superstition. Soon the idea of magic powers came to be entertained, and an unreflecting reverence for, and fear of, the medicine man himself accompanied it. From such a stage to the practice of the ceremonies of witchcraft the way is short. The administration of the remedies as well as their collection was soon invested with superstitious ceremonies and incantations, which held their sway among the people till the dawn of a brighter light dispersed the clouds of ignorance.

Some such course of development may give us an explanation of much that exists in the early herbals. The little that is shown to be actually known is inextricably mixed with descriptions of magic rites and ceremonies, calculated to strike awe into the breast of the uneducated spectator. Nor is this feature confined to the ancient books, for there are traces of it even so late as the writings of Gerard in the seventeenth century. A collateral development of it was the attributing of mysterious properties to the plants themselves, the elaboration of a system of charms, phyltres and other mysterious concoctions, all aiming at the extension of power in the hands of medicine men, witch-doctors, or the

members of such priesthoods as were at the time existing. To this was soon added an association of the plants with the superstitions of the time, the worship of the deities, and the dedication of particular plants to the special gods to whom men committed the various phases of their lives. From this Cimmerian darkness of empiricism, however, by feeble gropings men gradually made their way to the light, and the truth gradually emerged from the mass of error. The superstitious and the magical gradually gave place to something sounder, and by slow and tortuous steps medical practice became based on science. In Greece this period of the evolution of the healing art was far back in the early times. In the days before Plato and Aristotle one Thrasyas flourished—a man who appears to have been well versed in a fairly scientific pharmacology and to have practised medicine on similar lines. More than 300 years before the Christian era the writings of Hippocrates indicate the existence of a regular practice of medicine and the adoption of an accurate system, for they were the subject of study in the early physic schools of Greece. The *Materia Medica* of Hippocrates appears to have been derived from some 300 plants. In Western countries, particularly in England, we can find evidence of a similar but much later progress of the same kind and in the same direction.

But the development of the primitive botanical idea was not conducted on these lines alone. By what steps another path had been discovered we cannot now determine, for very little of the literature of ancient Greece bears upon the subject. We find, however, that by the time of Plato and Aristotle a natural philosophy had come into being, and with it such a development of botanical knowledge as may well be called a science of botany. It was, however, associated with ideas that were more philosophical than scientific, and much of what it taught was purely speculative. Aristotle especially was an expounder of this philosophy, the dominant ideas of which led him into strange mistakes in his interpretations of vegetable structure. His friend and pupil Theophrastus was largely free from these philosophical speculations. By some means he had cast off such a yoke and was an exponent of the scientific side of botany, as it was in those days—the first, perhaps, to merit the name of botanist.

It has been customary of late years, mainly under the influence of the writings of Sachs, to decry the eminence of Theophrastus and to contend that like Aristotle he subordinated his botanical knowledge to his philosophical speculations. Happily his writings

are extant, not only in the original Greek, but in a Latin translation. A critical examination of them shows that herein Sachs did him great injustice, and entirely justifies the appellation that Linnæus gave him—the Father of Botany.

Theophrastus was not acquainted with more than 500 plants, but he cultivated them in a private botanic garden of considerable extent, to which he attracted a numerous following of pupils or disciples. He has left on record the main features of his teaching, which was conducted in the open air with full access to the plants.

He had a very accurate knowledge of the principles of morphology, distinguishing the external members of plants much as we do to-day. He was familiar with the laws of branching and the varieties of construction met with among the different kinds of inflorescence. He grasped the importance of those features of floral structure that were long afterwards made use of by De Candolle in forming large groups constituting the sub-classes of his system of classification. He had very clear ideas as to the nature of the fruit and seed, and was the first to introduce into terminology the word *pericarp*. He was familiar with the general lines of the work of the different organs of the plant, though this knowledge of physiological processes was rudimentary. Though he promulgated no system of classification, he apprehended the importance of many of the morphological points which were afterwards made use of in taxonomy. His knowledge of vegetable anatomy extended far, as we must admit if we bear in mind that he had the aid of none of the appliances now in use. Without any microscope or lens, he described many of the peculiarities of the structure of stems, roots, and leaves, and was acquainted with annual rings and with secondary thickening.

From his writings we find that others before him had become familiar with many features of vegetable life. Among them Cleidemus seems to have been acquainted with a rudimentary vegetable pathology, and to have studied, probably from the economic point of view, the diseases of many trees and shrubs. Another writer was Hippon, who studied problems that have not yet lost their interest, the questions of the influence of cultivation on variation, the problems which were, in substance though not in name, those of evolution and reversion.

Though Theophrastus thus had predecessors, we find but little evidence of their influencing him ; the accusation of Sachs, that he was so much under the influence of the philosophic teaching

of Aristotle that he could not get free from it even in the examination of his plants, fails to receive any substantiation from his writings, which stand out conspicuously as those of a master as well as an original thinker, and justify the name Linnæus gave him. His books were really the foundation on which much of the botany of the sixteenth century in Western Europe was built.

But for the source of the early botany in England it is useless to look back to Theophrastus. The road seems to have led rather from Hippocrates, and to have received contributory paths from the Asiatic lands of the Far East and the mysterious interior of Arabia. The writings of Hippocrates seem to mark the assumption of a regular practice of medicine, for they were taught in the early physic schools of Greece. Hippocrates enumerated about 300 plants used in medicine in his time. Four hundred years later Dioscorides described more than twice that number, and thence onward the Arabian physicians added many more.

While the development of medical botany and the incoming of the herbal were thus making progress the scientific work of Theophrastus fell into neglect and for a time oblivion, and so far as England was concerned, it had very little direct influence on the progress of events. Long afterwards a revival gradually came about; the English botanists were influenced by men like Cæsalpino, Jung, the Bauhins, and others of the continental writers, upon whom the spirit of Theophrastus seemed to rest. But when the light of history began to dawn upon England, or rather upon Britain, with the writings of Cæsar and Pliny the Elder, a certain degree of development had taken place, if indeed it is possible to speak of a development of botany when the land had only reached the stage of superstitious mysticism under the influence of the Druids. Even earlier than the time of Hippocrates there is evidence from the laws of Dyonwal Mœlmud, which date from about 430 B.C., that the art of medicine was protected and encouraged by the authorities of the time. It is possible that the Druids became possessed of some acquaintance with the medical lore of the Greeks through the Mediterranean traders, for certain Welsh writers mention the name of Hippocrates, and there is some evidence that the physicians of the time held his work in high esteem. Botany, such as it was, had found a lodgment in the hands of the Druid priests, who were not only acquainted with the rudiments of the healing art but, according to Strabo, had some knowledge of physiology. Most of our information as to their treatment of disease and as to various ceremonial

observances in which plants were concerned is derived from the Roman writers, particularly Pliny. According to him the Druids devoted considerable time to the study of the medicinal properties of plants, and they believed some of the latter to be endowed with magical virtues. Their pharmacopœia was not a large one, the most prominent of the plants to which they attached special virtues were the mistletoe, the vervain, the selago, and the samolus.

The ceremonies associated with the mistletoe have been most frequently quoted. The Druids were familiar with the fact that it grew upon different trees, but the reverence which they paid to the plant was restricted to that which was found upon the oak. This they deified, and approached it only in the most devout and reverential fashion. Their reverence seems to have been associated rather with the oak than the parasite, for, according to Pliny, they considered that whatever grew upon this tree was sent from heaven and was a sign that a deity had selected the tree. Moreover, the fruit was regarded by them as the emblem of fecundity, for the acorn in its cup was one of the earliest phallic emblems, the former being regarded as the symbol of the masculine and the latter of the feminine attribute.

Pliny thus describes the druidical ceremony of gathering the mistletoe. "As the mistletoe is seldom to be met with, when found it is fetched with great ceremony on the sixth day of the moon, which with them begins the months and years, and the period of thirty years, which they term an age, for at that season the moon has sufficient influence, and is about half full. They call this plant in their own language 'All-heal,' and after preparing for the sacrifice and feast under the tree, they bring up two white bulls whose horns have then been bound for the first time. The Archdruid, habited in white, mounts the tree, and with a gold sickle cuts the mistletoe, which is received in a white cloth. The victims are then sacrificed, and prayers are offered to the deity to render his gift favourable to those to whom they distribute it. They suppose that it renders fruitful every animal that drinks a decoction of it, and that it is a remedy against all sorts of poisons."

Its medicinal virtues, when gathered with this ceremony, were thus held to be concerned with the maintenance of fertility, but other qualities also were associated with it. It was held to be a remedy for epilepsy.

The vervain was another of the druidical sacred plants, but its identification is a little difficult. It has been said, with consider-

able probability, that it was the verbena, but there is some room for doubt, as this name was applied to many plants used about the altar in sacrificial observances. But whatever it was, its gathering was associated with various mystic rites. The earth from which it was to be taken had to receive a libation of honey, and the plant was then dug out with the left hand, after the performance of certain ceremonies. The time was always at the rising of the dog-star, in the absence of both sun and moon. When uprooted the plant was waved ceremonially in the air, after which the leaves, stalks, and roots were dried separately in the shade. So prepared, the vervain was a cure for fevers, an antidote to snake-bite, and a charm to conciliate friendship.

Still more doubtful is the identification of "the Selago." Pliny was very vague in the description he gave of it, saying it was "like savin." Cæsalpino considered it a *Sedum*; Guilandinus thought it an *Erica*. Most authors have held it to be *Lycopodium Selago*. It was to be gathered with the left hand by a Druid clad in white, and having his feet bare; it was not to be cut with iron, nor touched with the naked hand. Its gathering was to be preceded by a sacrifice of bread and wine, and to be attended by various religious or magic ceremonies. It was then regarded as an efficacious remedy for diseased eyes, and held, further, to be a charm against all misfortunes. The Welsh name for it was the "Gift of God."

The samolus has been variously associated with a species of *Veronica* and with an *Anemone* resembling the pasque-flower, so that its identity is not at all well established. It was given to preserve oxen and swine from diseases.

Other plants known to the Druids include the "herba Britannica" of Dioscorides and Pliny, which Cæsar spoke of as a remedy for scurvy. It has been ascribed by different authorities to *Polygonum persicaria*, and to *Primula auricula*; Turner held it to be *Polygonum bistorta*, and Ray identified it with *Rumex aquaticus*.

Sorbus aucuparia was often planted by the Druids near their monolithic circles and their cromlechs; it was said to protect houses from evil spirits, while a little piece carried on the person was a charm against witchcraft.

Holly, ivy, and the birch were also among the sacred plants of the Druids.

Apart from the writings of Pliny and Cæsar there is but little evidence existing as to the rest of the flora known to the Britons.

No written records have been preserved, but some traces are to be met with among the mediæval writers. A list of names was recorded by Gerard, said to have been communicated to him by a certain Mr. Davies of Guissaney in Flintshire; others, chiefly Irish, were preserved in Threlkeld's *Synopsis*; a few Erse names were recorded by Lightfoot, on the evidence of Stuart. Threlkeld's list contained nearly 400 names.

We have no information as to the state of botanical knowledge under the Roman occupation. The manuscripts of the Greek writers as well as of Pliny were very scarce, and no progress of knowledge was noticeable. With the advent of the Saxons a certain advance was made, though not a great one. The position during this period is referred to in 1772 in a letter from Dr. Ducarel, F.R.S., to Dr. Watson "upon the early cultivation of Botany in England" from which a few extracts may be taken. "The sciences, we know, are subject to revolutions. But is it not a very extraordinary one that Botany, so useful to mankind, and so well known to the ancients, should for some ages abandon Europe and remain almost unknown there till the sixteenth century, when it is supposed to have suddenly revived, and has since, by the industry of the moderns, been brought to the highest perfection? The truth, however, is that Botany returned into England long before this æra. It was brought back here by the Saxons, since whose time I shall endeavour to show that it hath always flourished, more or less, in this kingdom. I found my opinion upon the authority of the four following Saxon manuscripts: Two in the Bodleian Library, viz., No. 4123, HERBARIUM Saxonice; No. 5169, LIBER MEDICINALIS *continens virtutes Herbarum* Saxonice. And two others in the Harleian Library, viz., No. 5066, entitled HERBARIUM Saxonice: No. 585, *Tractatus qui ab Anglo-Saxonibus dicebatur* LIBER MEDICINALIS: scil. L. Apuleii Madaurencis Libri de Virtutibus Herbarum, Versio Anglo-Saxonica."

The date of this translation is said by Pulteney to be of the tenth century, when, in consequence of the spreading of Christianity in Britain, communication between this country and Rome became more frequent, and learning became the object of the eager pursuit of many in the golden age of Alfred. Though we have no trace of the publication of any Saxon herbal, we find in Saxon manuscripts more than one translation of the *Herbarium* of Apuleius, and we have reason to believe that it was the book most in use and most generally popular in Britain. Apuleius, who lived in the age of the Antonines, was born at Madura in

Africa, and after studying at Carthage and at Athens settled in Rome and devoted himself to philosophy and medicine. His work, written about A.D. 200, was the chief authority in the Middle Ages.

The best view of Saxon wortcraft preserved for the student is afforded, however, by a later version of this book together with the Saxon *Leech Book*, edited by Mr. Cockayne for the Rolls Series. The manuscript of the *Herbarium* selected by Cockayne as the basis of his text, Bibl. Cotton Vitellius, ciii, dates from about the year 1250. It received considerable damage in the great fire at Ashburnham House in 1731, and to supply the lacunæ in its text it has been carefully collated with the Bodleian and other manuscripts of the *Herbarium*. The latter part of the *Herbarium* contains a number of passages drawn from a Latin translation of Dioscorides.

Apuleius gave in his *De Herbis, sive de Nominibus ac Virtutibus Herbarum* the names of medicinal herbs in the Greek, Latin, Egyptian, Punic, Celtic, and Dacian languages. After each name followed a short description of the plant, its place of growth, and its properties, together with the diseases for which it was considered remedial.

The Saxon manuscripts followed the general plan of the *De Herbis*, but gave only the Saxon and Latin names, many of which, however, were inaccurate. For example, "*Centaurea major, i.e.*, Churnel the greater" of the *Herbarium*, was properly *Chlora perfoliata*, while "*Centaurea minor, i.e.*, Churnel the less," was *Erythræa centaurium*. As an illustration of the mode of treatment we may take the description of "Betony, the wort," the first plant treated of. We are told that "It is produced in meadows and on clean downlands, and in shady places. It is good whether for the man's soul or for his body. It shields him against monstrous nocturnal visitors and against frightful visions." The roots of this wort were gathered in August and powdered for medicinal use. It was then deemed a remedy for sores, dim and bleared eyes, toothache, indigestion, nausea, snake-bites, and for "foot addle" or gout. A decoction of the powdered root seems to have been drunk in most cases, but poultices of betony are recommended for sore throat and gout.

Other remedies for gout, which seems to have been a troublesome disease among the mead-drinking Saxons, were way-bread, tomentilla, powdered verbascum, groundsel, or pellitory pounded with lard and laid to the foot; also, of course, the mandrake, *Mandragora officinarum*, "the insane root that takes the reason

prisoner." The directions for gathering the mandrake are taken from Dioscorides: "It shineth at night altogether like a lamp: when first thou seest its head, then inscribe thou it instantly with iron lest it flee from thee; its virtue is so mickle and so famous that it will immediately fly from an unclean man when he cometh to it, hence as we before said do thou inscribe it with iron, and so shalt thou delve about as that thou touch it not with the iron, but thou shalt earnestly with an iron staff delve the earth. And when thou seest its hands and its feet" (alluding to the curious tendency of the mandrake to assume a certain similarity to the human figure by giving off two lateral branches above and ending in two limbs below) "then tie thou it up. Then take the other end and tie it to a dog's neck, so that the hound be hungry; next cast meat before him, so that he may not reach it except he jerk up the wort with him. Of this wort it is said that it hath so mickle might that what thing so ever tuggeth it up, that it shall soon in the same manner be deceived. Therefore, as soon as thou see that it be jerked up, and have possession of it, take it immediately in hand, and twist it, and wring the ooze out of its leaves into a glass ampulla or pitcher."

These directions for plucking the mandrake are as old as Josephus, who says in his *Wars of the Jews*, "They dig a trench quite round about it till the hidden part of the root be very small; they then tie a dog to it, and when the dog tries hard to follow him that tied him, this root is easily plucked up, but the dog dies immediately, as if it were instead of the man that would take the plant away; nor after this need any one be afraid of taking it into their hands." He goes on to say, "Yet after all this pains in getting, it is only valuable on account of one virtue it hath, that if it be only brought to sick persons, it quickly driveth away those called Demons, which are no other than the spirits of the wicked, that enter into men that are alive, and kill them unless they can obtain some help against them."

The Saxon leech held the mandrake to be a specific for "devil sickness" and the evil eye, but he was aware also of its emetic, purgative, and narcotic properties.

The Saxon remedies for insanity were many and curious. The lunatic was given a decoction of *Teucrium polium* mixed with vinegar, or *Ranunculus acris* was tied with a red thread about his neck when the moon was on the wane in April or the early part of October. A more sovereign remedy was the pæony. If laid over the lunatic as he lies, we are told "Soon he upheaveth him-

self whole, and if he hath this wort with him, the disease never again approaches him." The *Leech Book* contains another mode of cure, certainly sufficiently drastic. "In case a man be lunatic, take the skin of a porpoise, work it into a whip, swinge the man therewith, and soon he will be well. Amen."

Of *Ranunculus sceleratus*, Apuleius tells us gravely, "Whatsoever man fasting eats this wort, leaves his life laughing." The leech made poultices of it to purify wounds and running sores, and drive away swellings and warts. *Ruta montana*, "herb of grace," was used by him for gastric troubles, as also were pennyroyal and rosemary. For the stone, he administered infusions of *Saxifraga granulata* or *Glechoma hederacea*. Heliotrope and woad he thought good for snake-bite, and he gave way-bread for the bite of a mad dog. Ivy, he held, cured the dropsy. For the dread disease of leprosy it was his custom to take *Euphorbia lathyris* and smear the leper with the heads of this wort, sodden in tar. For sea-sickness, he gravely advised the vigorous smearing of the person with a preparation of pennyroyal and wormwood, pounded with oil and vinegar. It is interesting to note that the lily was already naturalised in England, and its pounded leaves used to reduce swellings.

The *Leech Book*, edited by Cockayne, is an earlier production than this Saxon version of Apuleius, dating from the latter half of the tenth century. The author seems to have been acquainted with the writings of some of the Greek doctors, but for the most part, while adopting diagnosis and theory from the Greek medical writers, he practises as a herbalist, nor does he neglect the question of diet. The sick man is to take "light meals and juicy broths, and beaten eggs, and bread broken in hot water, and periwinkles removed from the shell."

In a very interesting passage, we are told that King Alfred sent to Helias, the patriarch of Jerusalem, for new remedies. He recommended to the King various drugs sold in the Syrian drug shops or apothekæ—scammony, gutta ammoniaca, gum dragon, aloes, galbanum, balsam, petroleum, and alabaster.

A jejune and ridiculous compilation is the translation of the *Medicina de Quadrupedibus* of Sextus Plautus, from which it would appear that the Saxon leech had faith in the medicinal virtues of neat, fox, hart, hare, he-goat, ram, boar, wolf, hound, lion, bull, and elephant. The raw beef-steak, the schoolboy's remedy for a black eye, is anticipated by the recipe "To remove ugly marks from the face, smear with bull's blood, it taketh away all the marks." But for the most part, the recipes are as useless

as the one enjoining the binding of a new goat's cheese round the head for the cure of headache.

The Saxon leech trusted much in charms, of which Cockayne gives a variety, but in this matter he was anticipated by Dioscorides. Following him, he says of *Ricinus communis,* "If thou hangest some seed of it in thyne house, or have it, or its seed, in any place whatsoever, it driveth away the tempestuousness of hail, and if thou hangest its seed on a ship, to that degree wonderful it is, that it smootheth every tempest. This herb thou shalt take, thus speaking, 'Wort Ricinus, I pray that thou be at my incantations, and that thou turn away hail and lightning and all tempests, through the name of Almighty God, who hight thee to be produced.'"

The popularity of Apuleius lasted through the Middle Ages, and the *Materia Medica* of Dioscorides gave rise to a crowd of commentators. But of the 700 plants which Dioscorides described a large number cannot be identified, for his descriptions were chiefly confined to colour, size, mode of growth, and comparison of leaf and root with those of other plants assumed to be well known, and therefore left undescribed. Moreover, his plants were those of Greece and unlikely to be found growing in Britain. But the Saxon translator copied slavishly from his originals instead of studying British plants in the field. However, both the *Herbarium* and the *Leech Book* show that the Saxon leech was at bottom a herbalist, and his craft "wort cunning."

When we pass onwards from Saxon times we find little evidence of any real progress in the direction of the development of botanical science or even herbal art. A few scattered manuscripts can be noticed, no one of which, however, is more than a list of names of comparatively few plants or can, by any stretch of imagination, be called scientific. The historian Henry of Huntingdon, who flourished in the time of Stephen and Henry II., left a manuscript of eight books, *De Herbis, de Aromatibus, et de Gemmis.* This is now in the Bodleian Library. Arviel left a manuscript, *De Botanica, sive Stirpium Varia Historia*, which was written towards the end of the thirteenth century. About the same date were some writings alluded to by Ducarel in the letter quoted. "From this time I have met with no MS. concerning botany till the thirteenth century, when Bishop Tanner mentions three MSS. on this subject, written by Gilebertus Legleus, sive Anglicus, a physician, who flourished in the year 1210, entitled (1) De Virtutibus Herbarum MS., Bodl. Digt. 75; (2) Gilberti Liber de

Viribus et Medicinis Herbarum, Arborum et Specierum, MS. olim Monast. Sion ; (3) De Re Herbaria, Lib. i. The Bishop likewise mentions one John Ardern, a famous surgeon, who lived at Newark in Nottinghamshire from 1349 to 1370, as the author of a MS. (now extant in Sir Hans Sloane's Library), entitled Volumen Miscellaneorum de Re Herbaria, Physica, et Chirurgica. In the Ashmolean Library are the following MSS., viz., No. 7704, entitled A Treatise of Chirurgery, with an Herbal, etc., in old English 4to. 1438. And another, No. 7709, called An Herbary, etc., written alphabetically, according to the Latin names, in 1443; also No. 7537, entitled A Book of Plants and Animals, delineated in their natural colours on velom, Old English, A.D. 1504."

Pulteney quotes several other manuscripts of this age which are, or were, in various libraries, but as they did nothing to advance the knowledge of botany it is not necessary to mention them in detail. None of them were ever published, and accordingly they had little or no influence on the current thought of the time. Indeed, the whole period was one of darkness and torpor. It is extremely doubtful if any of these manuscripts exhibit any considerable portion of original matter ; they were presumably in the main extracts and compilations from earlier writers, and their general style may be gathered from the quotations already made from the earlier authors.

Pulteney refers, however, to a work which, from its widespread distribution in England, demands a passing notice. He says, "A book under the name of Macer's *Herball* seems also to have been in common use in England, before the æra of printing. Authors do not allow it to be the production of Æmilius Macer quoted by Ovid, but of much later date, and by some it is ascribed to Odo, or Odobonus, a physician of the later times, and probably a Frenchman. This barbarous poem is in leonine verse, and is entitled *De Naturis, Qualitatibus, et Virtutibus Herbarum.* Divers manuscripts of it are extant in the English libraries, as at Cambridge, in the Bodleian, Ashmolean, and Sloanean collections. It was translated into English, as Bishop Tanner informs us, by John Lelamar, master of Hereford School, who lived about the year 1373. His manuscript is referred to as in Sloane's Library. Even Linacre did not disdain to employ himself on this work. 'Macer's Herbal, practysyd by Doctor Linacre, translated out of Latin into English, London 12mo.' Ames mentions an edition of it printed in 1542; and Palmer, one without a date, printed by Wyre. This jejune performance, which is written wholly on

Galenic principles, treats on the virtues of not more than eighty-eight simples. I shall not detain the reader by dwelling on other authors of this class, whose names I have before recited; it will be sufficient to observe that, fettered as were the theories of this time with astrology, and a strange mixture of the Galenic doctrine of the four elements, it extended its influence, not to the human body alone, but to all the instruments of physic. Not even a plant of medicinal use but was placed under the dominion of some planet, and must neither be gathered nor applied, but with observances that savoured of the most absurd superstition."

CHAPTER II

THE AGE OF THE HERBALISTS

William Turner, the Father of English Botany

From this chaotic mixture of magic, astrology, and the healing art, the emergence of anything like botanical science was, as may well be imagined, extremely slow. Its foundation was difficult, its development fanciful and irregular. The mists of superstition were dispelled only with great difficulty, and not till the results of the work of a few men of the tenth century appeared could botanical science claim even a beginning. On the Continent of Europe progress can be noted earlier than in England, but the pioneers can be traced no further back than Brunfels in 1530, Fuchs in 1542, and Bock a little later. They brought forward for the first time the idea of making and publishing lists of plants or *herbals*, and upon this plan the foundations of modern botany were laid. Even in these lists we find nothing more than separate descriptions of the plants which either found their home wild in Germany, or were cultivated there in gardens. The arrangement of the plants was primitive in the extreme; there was no attempt to indicate relationship, but at the best only an alphabetical catalogue. But while these defects were so marked the work showed a very important advance upon that of their predecessors in that clear description was aimed at, and was supplemented by wood-cuts to elucidate features which remained obscure after as minute a description as possible had been given. Before the time of Brunfels the principal botanical volume obtainable was the *Hortus Sanitatis* ascribed to Cuba, which dated back to the end of the fifteenth century. It was embellished with attempts at illustration, but they were frequently drawn apparently from fancy, or were borrowed from earlier authorities, so that they were often grotesquely distorted.

No doubt the closer association of plants with medicine awoke a sense of the necessity of clearing away the mists of speculation and tradition, and made evident the desirability of gaining a more definite recognition of properties likely to be of use in the healing art. Even after this important feature was

appreciated progress remained very slow, but as time went on advances were gradually made and the organisation of botany as a handmaid to medicine became possible. A feature of the transition from speculation to fact was the attention paid by the writers of the period to the possible identification of the plants they came across with the old descriptions of those which had been left in the works of Dioscorides, Galen, Pliny, and others of the ancient writers. This, however, does not apply to England, as there is great doubt whether these classical writings were at that time known to more than a few schoolmen in this country.

The writings of the early part of the sixteenth century, concerned thus with questions of such medical treatment as then prevailed, and indicating but a slow and halting emergence from the mists of superstition, were necessarily much more empirical than scientific. The advance which the herbalists inaugurated, however, was a great one, and one which put matters in train for still greater developments. The movement which was then originated in Germany spread to other countries, and brought into being what we may call the era of the herbalists. During this period we notice the origination and development of the physic garden, on which they mainly depended for their plants.

The first publication which exhibited England as taking a share in the new departure was *The Grete Herball*, which first appeared in the year 1516. It was hardly illustrative of progress even in the art of description, for it incorporated rather the older inaccuracies than the descriptions that came into vogue after Brunfels, some twenty-four years later. Still it is interesting as showing the standard of attainment of the time. It was printed by one Peter Treveris, but the name of its author has not been preserved. It appears to have been based on certain continental books, and particularly the *Ortus* or *Hortus Sanitatis*, to which allusion has already been made. It passed through several editions, the best known of which was published in 1526, under the following title: "The Grete Herball, whiche geveth purfyt knowledge and understandyng of all manner of Herbes and there gracyous vertues which God hath ordeyned for our prosperous welfare and helth, for they hele and cure all manner of dyseases and sekenesses that fall or misfortune to all manner of creatoures of God created, practysed by many expert and wyse masters, as Avicenna and other, etc. And it geveth full purfyte understandyng of the book lately printed by me (Peter Treveris), named the noble experiens of the vertuous handwarke of Surgery. Imprynted at London in Southwarke

by me, Peter Treveris, dwelling in the Sign of the Wodows, 1526, the 27th day of July."

The Grete Herball regarded the plants it recorded almost entirely from the medical standpoint, being said in the introduction to be "compyled and auctorysed by divers and many noble Doctours and expert Maysters in Medicynes." It dealt with the plants according to the qualities which the galenic mode of the time attributed to them, whether they were "hot" or "cold," "dry" or "moist," concluding the notice of each generally by a prolix account of the diseases to which the plant was held to be applicable, and the method of using it. The woodcuts with which it was illustrated were mainly copied from those of the *Hortus Sanitatis*, and some of them were absurdly unnatural. In the drawings of the mandrake, for instance, two perfectly human figures were represented, with the plant growing from the head of each. Its ideas of medical treatment may be represented by the following recipe, a study of which makes it not surprising that the apothecaries preferred to "get their recipes from the old wives that gather herbes, or from the grocers. . . ." "As agaynst bytinge of a mad dogge. As soon as ye be byten, go to the chyrche and make thy offrynge to our ladye, and pray here to helpe and heale the. Then rubbe the sore with a newe cloth tyll yt blede, and take three egges and bete them. Then take a cruse and fyll yt full of olyve oyle, and put the three beten egges therein and bete them all togyther wythout salte, and then take whyte cassie well clensed and sethe the egges therein wythout any oyle or grease, and styr it alway apace tyll they be well soden, and when all is well soden togyther eate the better halfe, and lay the other halfe on the wounde as hote as may be suffered, and ye shall be hole, and ye must fast three or four houres after and eate the plaster bye three or four dayes after."

Between the dates of the first and second editions of the *Grete Herball* another book appeared which was, in many respects, superior to it. It bore the name of Rycharde Banckes, but it is probable it was a compilation on his part. It achieved some popularity and passed through many editions, some of which, however, bore other names than the original. The first edition appeared in 1525.

Another book which appeared in 1550 was published by a priest named Anthony Ascham, and bore the appropriate title of the *Lyttel Herball*. On its title page it showed how poor a claim it had to be considered an advance upon its predecessors; it pro-

fessed to deal with "the properties of herbs, with certain additions at the end of the boke, declaryng what herbs hath influence of certain starres and constellations, whereby may be chosen the best and most lucky times and days of their ministration, according to the moon being in the signs of heaven, the which is daily appointed in the Almanack."

Pulteney mentions, in addition to these, another herbal published about the same time by a London printer named Copland. It appears, however, to have been a similar production, and to have contained little or nothing of botanical interest.

This unhappy condition of empiricism was slow to disappear. The influence of the German writers was appreciated only very gradually, and half of the sixteenth century had expired before any very substantial progress was made.

Upon such a scene as this, and with such a background of ignorance and superstition, we meet with the figure of the first great English botanist—great in comparison with any of his contemporaries, whether at home or abroad—William Turner, scholar, reformer, and dignitary of the Church, occupying high position, friend of the leaders of the state.

There is but a scanty biography of Turner extant. He was born at Morpeth early in the sixteenth century, and after some preliminary education he went up to Cambridge to study medicine. He graduated B.A. in 1529-30 and became a "poor fellow" of Pembroke College, then Pembroke Hall, in 1531. There is but little record of his early life, but we find that at Cambridge he came under the influence of Ridley, and embracing his tenets, gave himself up to theological instead of, or as well as, medical pursuits. He became an itinerant preacher of the reformed doctrines, and was soon a marked man among their exponents. It was not long before he fell into disfavour with Bishop Gardiner, and paid for his zeal and effort by a long imprisonment, which was followed by a voluntary exile from the kingdom. So far as we know, his connection with the University was never renewed. While he was at Cambridge his relaxation took the form of botanical inquiry. His original leanings towards medicine, no doubt, were in great measure responsible for this, but he became the more inclined to the pursuit from his recognition of the shortcomings of the only book available to him, *The Grete Herball*. He said he "could learn never one Greke neither Latin nor English name, even among the physicians, of any herbe or tree," such was the ignorance at that time. Of *The Grete Herball* itself he said

it was "full of unlearned cacographies and false naming of herbes."

We gather from his later writings that he was an enthusiastic plant hunter at this period of his life, and we get a few glimpses of the flora of Cambridge and its vicinity, *e.g.*, "the germander grown in gardens is called in Cambridge 'English Treacle.'"

When banished from the scene of his serious labours in the field of theology he threw himself again into his favourite pursuit. We cannot trace all the steps of his career, but we hear of him as a student of plants in the continental towns of Basle, Strassburg, Bonn, and Cologne, where the new movement of the herbalists was being actively developed. Italy also was in the van of progress; the first botanic garden had been opened at Padua in 1545, and Lucas Ghinus, the teacher of Cæsalpino, was at the height of his fame as a lecturer on Dioscorides and "the seeking out of herbs." Turner joined Ghinus at Bologna, and later took the degree of Doctor of Physic at Ferrara. On his departure from Italy he resided for some time in Switzerland, where he made the acquaintance and secured the friendship of Conrad Gesner, who formed a very high opinion of him, as is evidenced by an allusion to him in his book, *De Herbis Lunarriis*, printed in 1555. "Ante annos 15, aut circiter cum Anglicus ex Italia rediens, me salutaret (Turnerus) is fucrit vir excellentis tum in re medica tum aliis plerisque disciplinis doctrinæ, aut alius quispiam vix satis memini, etc."

Turner's exile from England, thus profitably employed, ended at the death of Henry VIII. The Duke of Somerset, made Protector during the minority of Edward VI., had long been in sympathy with the botanical investigations of the time, and had established a large garden at Sion House. By this time Turner's reputation as a botanist or herbalist was recognised, and he was esteemed as a man of science as well as a theologian. On his return to England he was incorporated Doctor of Physic at Oxford in 1551. The Protector placed the garden at Sion House under his charge, to his great gratification, for it was of the greatest use to him in a work he had for some time been meditating, the production of a new herbal. There are frequent references in his writings to this garden, always couched in terms of considerable eulogy.

The old theological aspirations of his earlier years still possessed Turner, and under the Protestant régime of Edward VI. he became again the divine as well as the man of science; being soon noted as a powerful preacher and writer in advocacy of the doctrines of

the Reformation, his preferment in the Church was rapid; he became in quick succession Prebendary of York, Canon of Windsor, and Dean of Wells. The death of Edward VI. brought about a turn of the wheel, and he deemed it wise to retreat to the Continent, where he lived during the reign of Mary I. The cloud soon passed, however, and on returning to England he was restored to all his ecclesiastical preferments by Elizabeth. He seems to have been at one time a member of the House of Commons. The last years of his life were uneventful, being spent by him partly at Wells and partly in London. Botanical work constituted at once the employment and the amusement of his leisure. He had a botanical garden at his deanery, and another at Kew. He speaks of the latter in his *Herball*, saying that *Cicer* was growing in it. The reference seems to have given rise to the notion that this garden was the forerunner of the present national institution, which was not the case. The preparation and publication of his great *Herball* occupied him nearly to the time of his death, which took place in 1568.

In criticising Turner's botanical work we must necessarily bear in mind the condition of botany when he took up its study. Even the plan of scientific investigation was wanting. The quotations we have made from *The Grete Herball* show how little importance was attached to accurate descriptions of plants, and how they were all obscured by fanciful and superstitious beliefs in their various potencies and suitabilities for the treatment of various diseases. Astrology too played a part in allocating to them their supposed specific virtues. From all this obscurantism Turner shook himself free by his own practically unaided efforts. We must further remember that he put more prominently before him his theological studies and the duties of his clerical offices than his pursuit of botanical knowledge. He says as late as 1564 in the dedication to the company of surgeons of the third part of his *Herball*, "Being so much vexed with sickness and occupied with preaching, and the study of divinity, and exercise of discipline I have had but small leisure to write Herballes."

Turner was not so slavish an adherent to the dicta of Dioscorides and Pliny as were many of the continental writers. In the more advanced countries of Europe the desire to recover the medicinal plants of the Greek physicians led to the comparative study of a great variety of the plants indigenous to each country, and in Italy, Germany, and the Netherlands the compilers of herbals employed themselves in the careful examination of the plants

they described. The merits of each new herbal were held to depend on what the herbalist added from his own researches to the observations of his predecessors, all having, however, as their chief object the identification of the plants with the old Greek simples. Turner, however, used the ancients rather roughly, preferring, as he says, to give credit rather to his own experience than to "Pliny's Hearsay." "Because," he says in another place, "I would not be like unto a cryer that cryeth a lost horse in the market, and telleth all the marks and tokens that it hath, and yet neither saw the horse, neither could know the horse if he saw it. I went into Italy and into divers parts of Germany to know and see the herbes myself, and to know by practice their powers and working, not trusting only to the old herbwives and apothecaries, as many physicians have done of late yeares, but in the matter of simples myne owne eyes and knowledge." He carried out very conscientiously the statement just quoted, few of the plants described by him having been so described without his having seen them growing.

Turner's own botanical writings seem to have begun in 1538, with a small treatise of 20 pages, entitled *Libellus de re Herbaria novus*, which may be regarded as the first English book on botany. This was followed in 1544 by the appearance at Cologne of a small octavo volume bearing the title of *Historia de Naturis Herbarum Scholiis et Notis vallata*. A third work, dedicated to the Protector, was published while he was at Sion House in 1548, "Names of Herbes in Greke, Latin, English, Duche, and Frenche; with the commune names that Herbaries and Apothecaries use." But he made no impression in the botanical world till 1551, when the first part of his *History of Plants* appeared in London, in the form of a black letter folio, illustrated with the figures of most of the plants, and bearing the title "A New Herball, wherein are contayned the names of Herbes in Greke, Latin, English, Duche, Frenche, and in the Potecaries and Herbaries Latin, with the properties, degrees, and natural places of the same gathered." Part II. was published at Cologne with a second edition of Part I. in 1562, during the author's second exile, and both were reprinted in 1568, together with a third part which bore the title "The third part of Wm. Turner's Herball, wherein are contayned the herbes, rootes, and fruytes whereof is no mention made by Dioscorides, Galene, Plinye, and other old authors." This last volume was published separately at Cologne in 1564, because replicas of the woodcuts of plants in it could be obtained there, the original

wood blocks being, in all probability, the property of the printer. These woodcuts were in part the same as those that formed the illustrations of the first edition of Fuchs, first printed in 1545, and drawn by Albert Dürer. Turner added about ninety new figures; one of these was a drawing of the lucerne, which he is supposed to have introduced into England. He called it the horned clover.

In the preface to the first part Turner pays a tribute to Musa, Ruellius, Fuchs, Gesner, and Bock, who, he says, "have greatly promoted the knowledge of herbes by their studies, and have each deserved very much thanks, not only of their own countries, but also of the whole commonwealth." He goes on to complain that though there are "private herballs and bookes of simples by learned men in England who have as much knowledge of herbes as diverse Italians and Germans, the apothecary, for lack of knowledge of the Latin tongue, is ignorant of herbes, and putteth either many a good man in jeopardy of his life, or marreth good medicines." It was for the use of apothecaries, and also of physicians, many of whom had no knowledge of the Greek writers on Materia Medica, that this Early English botany was written, and like the Early German herbals one of its objects was to identify the Materia Medica of the ancients, particularly of Dioscorides. How difficult a task this was may be gathered from the fact that the *Iris* of Dioscorides was identified by Fuchs with the charlock, by Ruellius with the vervain, and by Gerardus with the watercress. Turner adds naïvely "A man may use any of them."

Turner showed his appreciation of the relation of botany to medicine by dedicating the third part of the *Herball* to the company of surgeons. He added to the dedication the following comment: "The knowledge of herbes, trees, and shrubs is necessary for physicians and apothecaries, without the knowledge whereof they cannot duly exercise their vocation, for how can he be a good artificer that neither knoweth the names of his tools neither the tools themselves when he seeth them."

Among the exotic subjects treated are *cassia fistula, cubebs, guaiacum, nutmegs, myriobalans, nux indica, nux vomica, sarsaparilla, senna, tamarinds, and "the noble herb rhubarb."* The arrangement of the *Herball* is alphabetical, according to the Latin names of the plants described. After the descriptions usually follow the places of growth. The medicinal use of each plant is fully dwelt on, but is relegated to a separate section.

In an interesting passage Turner records that "Tragus (Bock), a Christian physician, doth not onlye say that ferne hath seed, but

writeth that he found upon midsummer even seed upon brakes." He then describes the collection of the "seed" whose true nature was not known till a much later period.

Of the mandrake Turner says, "The pedlars rootes which are counterfeited and made like little puppets, which come to be sold in England in boxes, with hair and such form as a man hath, are nothing else but foolish feigned trifles. For they are so trimmed of crafty thieves to mock the poor people, and to rob them both of their wyt and their money. I have at divers times taken up the rootes of mandrake out of the ground, but I never saw any such a thing upon them as are upon the pedlars rootes that are commonly to be sold in boxes. It groweth not under gallosses as a certayn doting doctor of Colon in hys physick lecture dyd teach hys auditors."

Turner's merits as a botanist are well summed up by Pulteney, who says, "He nowhere takes any doubtful plants upon trust, but appears to have examined them with all the precision usually exercised at a time when methods and principles now established were unthought of; everywhere comparing them with the descriptions of the ancients and moderns. He first gave names to many English plants; and allowing for the time when specifical distinctions were not established, when almost all the small plants were disregarded, and the *Cryptogamia* almost wholly overlooked, the number he was acquainted with is much beyond what could easily have been imagined in an original writer on his subject."

Turner laid much stress on the necessity for accuracy in the figures accompanying descriptions of plants. He frequently criticises adversely the drawings of Dioscorides, condemning many of them as erroneous. Referring to some mention made by Matthioli of a plant of which he gave no description, he says "he might have caused it to be paynted if he could not have come by the herbe greene."

It is interesting to gather from Turner's writings that England possessed some botanists worthy of the name who were contemporary with him. He specially mentions one Master Falconer who possessed a book of plants in which was included a specimen of glaux, brought by him from Italy. This reference points to a certain activity in "seeking for herbes" and their preservation in the dried condition—in fact to the formation of herbaria. No sufficient record of their work, however, has survived.

The publication of Turner's *Herball* marks an epoch in English botany. It was in fact the first English book that had a title to

be called botanical, and it vindicates the claim made subsequently by other writers that Turner is to be regarded as the first English botanist. It is strange to notice that the distinguished herbalists who followed him during the later years of the same century, Gerard, Johnson, and Parkinson, say very little of him in their writings. Gerard speaks of him personally with appreciation, but gives little attention to his work. A century later Ray speaks of him in a way that shows he was sensible of what botanical science owes to him, calling him a man of solid erudition and judgment.

In the modern estimation of Turner the botanist overshadows the theologian and dignitary, a strange reversal of what he would himself apparently have desired. His writings in the field of theology and classical learning were numerous. He contributed many polemical and religious treatises, written from the point of view of the reformer, in support of the tenets of the Reformation. He collated the translation of the Bible with Hebrew, Greek, and Latin copies, and corrected it in many places. He also published many more strictly literary articles and translations, as well as some writings on the animal side of natural history.

Turner's name should be recalled to the memory of all botanists by the fact that it was given by Plumier to a genus of West Indian and American plants, a member of the group of the Passifloraceæ, from which genus the natural order Turneraceæ was subsequently formed.

Bulleyn

A few herbalists of much less note were contemporary with Turner. Dr. W. Bulleyn, a physician of some repute, and at one time in holy orders, published in 1562 "A book of simples, being an Herbal in the form of a dialogue, at the end of which are the cuts of some plants in wood." This work dealt in some detail with the medicinal virtues, real or imaginary, of the plants that occupied his attention, and he argued with some force in opposition to the views of many who disparaged the natural fertility of the soil in England. His writings were quoted by the leading herbalists who succeeded Turner, viz., L'Obel, Gerard, and Parkinson.

Penny

Dr. Penny, the friend of Gesner and Clusius, was also living at the same time. He had a great reputation as a naturalist; indeed, Gerard styles him "A second Dioscorides, for his singular know-

ledge in plants." He appears to have been a great collector, and to have introduced several plants into England, but beyond co-operating with the botanists named and with L'Obel and Gerard he did little to advance the science. He died in 1589.

Hill

About the same time there flourished one Thomas Hill, a miscellaneous writer, who was chiefly a compiler and translator for booksellers, but who practised astrology as well. Very little is known about his life, the dates of his birth and death being uncertain. There is little doubt that he died before the end of the century.

He was the author of several works which were partly written for the gardener and partly for the apothecary. The most important of them was "The Profytable Arte of Gardening, now the third time set fourth: to whiche is added a number of Secrettes with the Phisick helpes belonging to eche herbe, and that easie prepared: to this annexed two propre treatises, the one entituled The Marveilous Government, Propertie, and Benefite of the Bees, with the rare secrets of the Honny and wax; and the other the Yerely Conjectures meete for Husbandmen to Knowe." The first edition of this famous book, now very rare and valuable, was published about 1550; two subsequent editions appeared in 1558 and 1568.

Another work on gardening by the same author was "A most briefe and pleasaunt treatyse teachynge howe to dress, sowe, and set a garden" (1563). He wrote also a treatise on "the arte of grafting and planting of trees" in 1574.

CHAPTER III

THE AGE OF THE HERBALISTS—*continued*

L'Obel

The great defect of Turner's work was the utter absence of any attempt at methodical arrangement of his plants. This was characteristic also of the productions of continental writers, but the latter were the more prompt to try to remedy it. By and by, however, certain crude attempts at arrangement appeared. The first writers in whose works some efforts at classification were made were Dodoens and Clusius or De L'Ecluse, both in the Netherlands, and Dalechamps in France. The work of Dodoens especially calls for notice here, as, though not written in England, it was the foremost work of the latter part of the sixteenth century, and if it did not serve as the actual basis of the English herbals that followed it, its influence can be traced in varying degrees through most of them. Dodoens was physician to the Empress Maximilian and Rodolph II., and became professor in Leyden in 1582. He collected all his botanical writings into one volume in 1583; it bore the title *Stirpium Historiæ Pemptades Sex*, and both in the original and in several translations met with general acceptance. In the *Pemptades*, as in the less widely known writings of the time, the aim of the author was rather literary than scientific; he sought to give some sort of order to the mass of material he dealt with rather than to indicate natural relationship.

Contemporary with Dodoens was L'Obel, a botanist, who though born in Holland and resident on the Continent during his early life has a claim to rank among English men of science on account of the efforts he made to advance botany in this country for many years. Like Dodoens and Clusius he aimed to introduce order into his descriptions of plants, and may be said to have put forward the first sketch of a natural method of classification, though it was extremely crude and incomplete. He took into account the general habit, the external form, and the manner of growth of the whole plant or the flower, and dealing mainly with these points he put together large "families" or classes. These were necessarily very imperfect, and often quite inaccurate in the light of

later knowledge, but several of his families comprise groups which are almost identical with some of our present natural orders. The arrangement had some scientific value; indeed, in its final form in the *Observationes* it may be regarded as in some sort the basis of the *Pinax* of Caspar Bauhin of 1623 and the *Historia* of John Bauhin of 1650, both works of much importance. Still it lacked precision, for L'Obel did not lay down definitions or characters. He divided his plants into forty-four tribes, each of which comprised certain species, varying in number, which he described with care, giving with the description the time of flowering and the locality and habitat of the plant. At the head of each tribe he prefixed a synoptical view of all the species which he included in it, and gave to each the Greek, Latin, German, Dutch, French, and English name.

L'Obel was born at Lisle in 1538, and was a student of plants at Montpelier, under Rondeletius. All his life he was a lover of botany, devoted, however, from his youth rather to its medical side. During his early years he was a great traveller, and studied the plants of many countries. After a time he settled down at Antwerp as a physician, and rose to considerable eminence in his profession, becoming physician to William, Prince of Orange, and to the States of Holland. In about middle life he removed to England where his great works were written. He had the superintendence of Lord Zouch's physic garden at Hackney, and later was appointed botanist to James I. He appears to have been a friend of Turner, who, he says, gave him the seeds of the sea-kale. The date of his settlement in England is uncertain, but it appears to have been some time before 1570; he resided here thenceforward till his death in 1616.

Lord Zouch's garden at Hackney made some approach to the botanic garden of modern times. L'Obel endeavoured to arrange his plants according to their form resemblances. Beginning with long, narrow, simple-veined leaves, the grasses, he proceeded to the broader-leafed Liliaceæ and Orchidaceæ; then passed on to what we now know as the Dicotyledons, which he distributed into well-marked groups, including, however, the ferns among them because of the formation of their leaves.

L'Obel's first work, the *Stirpium Adversaria*, was published in 1570, two years after the appearance of the complete *Herball* of Turner, and was dedicated to Queen Elizabeth. In it we have the first presentation of his system, the leading features of which we have already sketched. In its production he had the co-

operation of Pena, though it is probable it was in the main the result of his own researches. His medical bent clearly appears in the book, indeed, he shows himself to be rather physician than botanist, for it professes to be an investigation of the botany and Materia Medica of the ancients, and especially of Dioscorides. To both these subjects L'Obel was able to make many additions, for his travels and researches on the flora of many countries enabled him to detect and correct numerous errors in the works of the older writers, particularly with regard to the dispensing of simples; while his more detailed knowledge of the plants of North-west Europe enabled him to make numerous additions to their catalogues. The work confirms what we know from other sources, that he was an ardent field-botanist, and explored many parts of England for plants, finding many members of the English flora for the first time. In particular he added a large number of new species to the list of the grasses. In some cases, however, he was not sufficiently explicit; many of the descriptions in the *Adversaria* being obscure, and the plants consequently impossible to identify with certainty.

A second part of the *Adversaria*, together with a reprint of the first part, appeared in 1605. It contained a list of 130 species of grasses, illustrated by figures and descriptions of those newly discovered; a record of a number of bulbous wild plants; a full account of the *Yucca;* and a catalogue from De L'Ecluse of thirty-eight varieties of the *Anemone.* It was, however, but a small part of the whole work. Prefixed to the volume were L'Obel's "Animadversiones in Rondeletii Methodicam Pharmaceuticam Officinam"; while it was made to include at the end several other medical essays written by himself and by Rondeletius.

During the interval between the appearances of the first and second editions of the *Adversaria*, L'Obel published the second great work which bears his name. This appeared in 1576 under the title *Observationes, sive Stirpium Historiæ, cui annexum est Adversariorum Volumen. In fol. cum Iconibus.* It was embellished with 1486 figures from blocks which had been cut for the works of De L'Ecluse, Matthiolus and Dodoens, and were supplied by Plautin of Brussels. The blocks are still to be seen in the Musée Plautin at Antwerp. In the *Observationes* we find the fullest expression of L'Obel's ideas of systematic arrangement, to which we have already alluded. Throughout he was guided by considerations of general habit, but he laid particular stress on the forms of the leaves. As in the arrangement of his garden he

begins with the grasses having narrow, elongated, simple leaves; thence he goes to the bulbous plants with leaves becoming broader while still elongated, as seen in the Liliaceæ and Orchidaceæ, and thence to the more diversified Dicotyledons. Among the latter he puts the ferns, doubtless misled by the form of the leaves and their resemblance to those of the Umbelliferæ. On the other hand, he points out the natural groups of the Cruciferæ, Labiatæ, and others. While his system was thus but the merest attempt at an introduction of the idea of classification it possessed at least some merit and, as we have seen, it afforded a starting place to the Bauhins a little later. L'Obel described his plants with some minuteness and quoted about each the observations of Dioscorides, Galen, and other classical writers, together with the ancient and modern applications of them to medicine. In an appendix we find a list of remedies drawn up by Rondeletius under the title *Formulæ aliquot remediorum Guillielmi Rondeletii, libro de internis remediis omissæ. De purgantibus sive attrahentibus medicamentis.* In these features of the work L'Obel's leanings towards the medical side of botany were evident.

In his later years L'Obel was occupied in the preparation of what he intended to be a much larger work than either the *Adversaria* or the *Observationes*. It was to have had the title of *Illustrationes Plantarum*, and to have been a complete account of botany in relation to medicine. Only a fragment of it was completed at his death, and not much of it ever saw the light. Some of his manuscripts came into the possession of Parkinson, and were incorporated into his *Theatre of Plants*. Part of the work was published by How in 1655, and was made by him the ground of a regrettable attack on Parkinson as will appear later.

Lyte

Two years after the appearance of the *Observationes*, and while the final part of the *Adversaria* remained unwritten, another herbal was published in London. The writings of Dodoens, as we have seen, exercised considerable influence in England, and a translation of them was the basis of the new work. This, published by Gerard Dewes in 1578, "At the signe of the Swanne, in Pawle's Churchyard," was a black letter folio, whose title page, adorned after the fashion of the time with figures of Apollo, Æsculapius, Artemisia, Lysimachus, Mithridates, Gentius, and the garden of the Hesperides, bore the following inscription: "A niewe Herball,

or Historie of Plants, wherein is contayned the whole discourse and perfect description of all sortes of Herbes and Plantes; their divers and sundry kindes; their straunge Figures, Fashions, and Shapes; their Names, Natures, Operations, and Vertues; and that not only of those which are here growing in this our countrie of Englande, but of all others also of foragne Realmes, commonly used in Physicke. First set foorth in the Doutche or Almaigne tongue by that learned D. Rembert Dodoens, Physition to the Emperour, and nowe first translated out of Frenche into Englishe by Henry Lyte, Escuyer."

Lyte, botanist and antiquary, was born in 1529, and was educated at Oxford, where, however, he took no degree. He was subsequently a student at Clifford's Inn, but does not appear to have practised law. He travelled a good deal and later lived the life of a country gentleman, managing his father's estate, to which he ultimately succeeded. He was a man of some position, for he bore a coat of arms, and he served in the office of sheriff during the reign of Mary I.

Apart from the preparation of the *Herball* he exercised very little influence on the progress of botany in England. He died in 1607.

The work was a translation of the French of De L'Ecluse, itself a translation from the *Cruijdeboeck* of Dodoens, and prefixed to it, it had the original preface and appendix, the latter being a collection from Dioscorides, Cato, and Pliny "relating to the rise and progress of botanical and agricultural knowledge among the Romans, and in commendation of gardens, with rules for laying them out and managing them to advantage." We shall advert later to Dodoens' work in connection with another herbal, but in the meantime we may point out that both Lyte and De L'Ecluse introduced certain modifications into the author's arrangement, though adhering mainly to the original plan. The book was much better than the earlier work of Turner, each chapter being divided into distinct sections dealing with the species, synonyms, localities, time of growth, etc. In this particular Lyte led the way for Gerard and Parkinson. The *Herball* included 1050 species, of which 870 were figured, the blocks being mainly copies of those of Fuchs, but about thirty were new, being added by the English translator. Among the latter was a representation of *Erica tetralix* of which Lyte drew the earliest figure recorded.

The French original which Lyte translated, bearing the date 1557, preserved in the British Museum, has copious manuscript

notes in Lyte's handwriting, which show that he was well versed in contemporary botany. He was not, however, an original writer. One great service which he rendered to English botany is recorded on the title-page of De L'Ecluse's *Dodoens:* "Henry Lyte taught me to speake Englishe." His object was a professedly benevolent one: that "even the meanest" of his countrymen, "whose skill is not so profounde that they can fetche this knowledge out of strange tongues, nor their habilitie so wealthy as to entertain a learned physition, may yet in time of their necessitie, have some helpes in their owne or their neighboures fieldes and gardens at home."

The high price of Lyte's *Herball* led, in 1606, to the publication of a quaint quarto "Ram's Little Dodoen: A briefe Epitome of the new Herbal, or Historie of Plants, lately translated into English by Henry Lyte, Esquire, and now collected and abridged by William Ram, Gent."

"Where the great booke at large is not to be had, but at a great price which cannot be procured by the poorer sort," says the preface, "my endevor hath bin chiefly, to make the benefit of so good, necessary and profitable a worke to be brought within the reach and compasse as well of you, my poor countrymen and women, whose lives, healths, ease and welfare are to be regarded with the rest, at a smaller price than the greater volume is."

Lyte's *Herball* went through several editions, the last appearing so late as 1678.

CHAPTER IV

THE AGE OF THE HERBALISTS—*continued*

Gerard

THE works of L'Obel and of Lyte both failed to supply what was needed by the practitioner in England. While they showed certain advances on Turner's *Herball* so far as their scientific position was concerned, they could not take its place; L'Obel's was written in Latin only, and so could command only a limited circulation; Lyte's was in many points deficient in accuracy. There was a great need for a new book, which, while preserving or securing the advances made in classification, should yet be of more general service, and should include the results of the discoveries of botanists since the date of Turner's work. This was the more felt in that botanical knowledge was still held to be mainly or wholly valuable as it could be applied to the healing art. The growing dissatisfaction with the writings then extant led to the appearance of what was in England the greatest botanical work of the sixteenth century, Gerard's *Herball*.

John Gerard was born in 1545 at Nantwich in Cheshire. Unlike Turner he received no University education; he was brought up to be a surgeon, and his career was in the main a medical one. His *Herball* was the outcome of his appreciation of the need for greater familiarity with the various simples at the command of the physician, and consequently with the various plants either indigenous to England or cultivated in gardens. He spent the greater part of his life in London in the pursuit of his profession, though in his early years he travelled through Russia, Sweden, and Norway, and possibly through the South of France.

He became a freeman of the Company of Barber-Surgeons in 1569, but there is no record of his admission to the livery.

His professional career was marked by considerable distinction; in 1598 and in 1607 he was examiner of candidates for admission to the freedom of his company, which at the time had much the position with regard to the regulation of medical practice as have the various medical boards of the present day. He reached the highest honour open to him in 1607, becoming then the Master of his Company.

During a good part of his life he resided in Holborn, where he maintained a private garden for the growth of simples. It contained nearly 1100 species of plants, native and exotic, a circumstance that excited some attention, a contemporary writing, " from whence it may appear that our ground would produce other fruits besides hips and haws, acorns and pignuts." This appears to have been occasioned by the fact that at the time " kitchen garden wares were imported from Holland and fruits from France."

Gerard was for some years superintendent of Lord Burleigh's gardens in the Strand and at Theobald in Hertfordshire. He made repeated efforts to get a more specially medicinal garden founded by his city company, but various obstacles were encountered from time to time, and the scheme never materialised. In 1604 he was granted a lease of a garden adjoining Somerset House, by the Queen Consort of James I., but he parted with his interest in it the next year to the Earl of Salisbury, the son of Burleigh. In the legal documents connected with this lease he is described as herbarist to James I.

The little garden of Gerard eclipsed that of L'Obel in fame. " Upon his proper cost and charges," wrote Dr. Baker, physician to Queen Elizabeth, " he hath had out of all parts of the world all the rare simples which by any means he could attain to, not only to have them brought, but hath procured by his excellent knowledge to have them growing in his garden, which as the time of yeere doth serve may be seen; for there you shall see all manner of strange trees, herbes, rootes, plants, flowers, and other such rare things that it would make a man wonder how one of his degree, not having the purse of a number, could ever accomplish the same." To this garden Gerard added from abroad all the varieties that he could obtain, and, in the adventurous age of Elizabeth, travellers were always coming and going, often bringing home seeds from abroad. From nearly all parts of the then known world there came to Gerard in London plants and seeds for the garden in which he laboured constantly " with the soile to make it fit for the plants, and with the plants to make them delight in the soile, so that they might live and prosper under our climate as in their native and proper countrie."

" That excellent herbarist, that painful and most curious searcher of plants and simples," Jean Robin, of whom in his works he made frequent mention, sent him seeds of many rarities. " This rare and strange plant," he records, for example, of barrenwort, *Epimedium alpinum*, " was sent to me from the French king's

herbarist, Robinus, dwelling in Paris at the syne of the blacke head in the streete called Du bout du Monde; in English, the end of the world." Robin, indeed, came over to England to see the garden in Holborn, and mightily pleased the Queen's physician by showing less knowledge of rare simples than Gerard, though in Paris "he was considered the onlie man."

De L'Obel's patron, Lord Zouch, sent Gerard rare seeds from Crete, Spain, and Italy, and he received "other rarities from the farthest parts of the world" through Lord Hunsdon. Nicholas Lete, "a worshipful marchant of London," added to the garden from Poland "orange tawnie gilliflowers," a variety of pink. He is reported to us as "greatly in love with rare and faire flowers, for which he doth carefully send into Syria, having a servant there at Aleppo, and in many other countries." This example was followed by Gerard himself, who sent his servant, William Marshall, into the Mediterranean as "Chirurgeon on to the 'Hercules' of London," thus obtaining several rarities for his collection. Most of Gerard's plants were, however, transplanted to his garden from their English habitats. In getting them together he was aided by Thomas Hesketh, of Lancashire, Thomas Edwards, an apothecary of Exeter, James Cole, a London merchant, "a lover of plants and very skilful in the knowledge of them," Dr. Bredwell, "a learned and diligent searcher of simples in the West of England," and Dr. Penny, a correspondent of Gesner and L'Obel, whom Gerard calls "a second Dioscorides," from his singular knowledge of plants. *Lilium Martagon*, "the mountain lillie," he received from his "loving friend Master James Garret, apothecarie in London," one of the earliest and most successful growers of the tulip, who "every season bringeth forth new plants of sundry colours not before seen, all of which to describe particularly were to roll Sisiphus's stone, or number the sands." He was a valued correspondent of De L'Ecluse, to whom he sent rare exotics.

In Gerard's time Holborn was still a village well separated from London. Between St. Andrew's Church and Chancery Lane there stretched a series of gardens and pasture lands. In this region, redolent with country scents, was situated Gerard's physic garden. It lay on the slope of the hill between Ely Place and the Fleet River. On every side were woods, fields, and hedgerows, "fields from the Charter House to Clerkenwell, with Finsbury and Moorfields stretching beyond the marsh by Aldersgate to the woods which lost themselves in Epping Forest. Over London

Bridge from Southwark to Lambeth Palace, Lambeth marshes without a habitation," Gerard could then gather from Gray's Inn Lane, mallow and shepherd's purse, sweet woodruff, bugle, and Paul's betony, and almost everywhere on the roofs grew the yellow wallflower and golden stone-crop. From the meadows near Gray's Inn he obtained the red-flowered clary, white saxifrage, the sad-coloured rocket, yarrow, lesser hawkweed, and the curious strawberry-headed trefoil. His *Catalogue* of the contents of the garden, published in 1596 and attested by L'Obel, contains the names of no less than 1033 species of plants.

Pulteney says that Gerard died in 1607, but the date appears a little doubtful. It was in this year that he became Master of the Company of Barber-Surgeons, and it is probable that he survived his year of office. The more likely year of his death was 1612.

When we turn to consider Gerard's writings we recognise that the production of the *Herball* throws all his other work into the background. An earlier publication, to which allusion has just been made, was an account of the plants growing in his garden in Holborn, which bore the title, " Catalogus Arborum, Fruticum, ac Plantarum, tum ingenarum quam exoticarum in horto Johannis Gerardi, civis ac chirurgi Londinensis nascentium. Impensis J. Norton, 1596.4°." It was dedicated to Lord Burleigh. The book soon came under the notice of L'Obel, and the first edition bore an attestation from him in the following terms :—" Herbas, stirpes, frutices, suffrutices, et arbusculas hoc catalogo recensitas, quamplurimas ac fere omnes me vidisse Londoni in horto Johanni Gerardi, chirurgi et botanici peroptimi (non enim omnes eodem sed variis temporibus anni pullulascunt, enascuntur et florent. Attestor Matthias De L'Obell, ipsis calendis Junii 1596."

From its rarity and careless printing it is surmised that he intended it primarily for distribution among his personal friends. It became so scarce that Pulteney says in his time only a manuscript copy of it remained extant, and this was in the collection of Sir Joseph Banks. Only a single copy of the printed work is now known to be in existence; it formerly belonged to Sir Hans Sloane and is preserved, as is also a manuscript copy, in the British Museum. The second edition, a small folio, much better printed, and bearing the date 1599, may still occasionally be met with, and the student will find both editions of the *Catalogue* of Gerard's garden preserved line for line and letter for letter, in a modern edition, privately brought out by Daydon Jackson in 1876.

The year 1597 was noteworthy as the date of publication of Gerard's masterpiece, the *Herball, or Generall Historie of Plants*, a large folio volume printed in London by John Norton. As this was the book on which his reputation rests, and was by far the most important work on botany of its time, some detailed account of it is necessary.

In its broad outlines it was based on the writings of Dodoens, which began to appear in 1552, and were continued from time to time for some thirty years. Dodoens then collected the scattered productions together and published them in one volume under the title *Stirpium Historiæ Pemptades sex. sive libri xxx.* Each pemptade was divided into five books, which observed some kind of order, but showed no acquaintance with any principle of classification, being, indeed, far inferior in arrangement to the *Observationes* of L'Obel. The pemptades were the following :—(1) A number of dissimilar plants in alphabetical order; (2) Flower-garden plants and the Umbelliferous tribe; (3) Medicinal roots, purgative plants, climbing and poisonous plants, ferns, mosses, and fungi; (4) Grain, pulse, grasses, water and marsh plants; (5) Edible plants, ground plants, esculent roots, oleraceous, thistles and spinous plants; (6) Shrubs and trees.

This work of Dodoens was a very popular book at the time, particularly among the physicians, as it retained much of the *Materia Medica* of Dioscorides and the Arabians, while it brought to its readers an acquaintance with the simples more recently discovered on the Continent.

In the interval between its publication in 1583 and the time (1597) when Gerard brought out his *Herball* the number of plants known had been very largely extended, and many new drugs had been discovered. Many of the continental books had been translated into either English or Latin. More material still was the increase of knowledge of foreign plants obtained by the travellers of the Elizabethan period, of whom Sir Walter Raleigh was the most conspicuous. It is hardly necessary to point out his traditional introduction of the potato into England, and to speak of his discovery, or at any rate his importation, of the tobacco plant. But apart from these he brought home large collections of other plants of less importance. Lord Edward Zouch and Lord Hunsdon, the Lord High Chamberlain, also had made considerable collections of exotic plants, which they placed at Gerard's disposal.

Gerard took the *Pemptades* as the foundation of his *Herball*, but he incorporated with Dodoens' work the results of the dis-

coveries that had been made in the interval, taking advantage, too, of what was pertinent in the writings of his contemporaries. He followed in many particulars the plan of L'Obel's *Adversaria.* The book contains more than 1800 woodcuts, of which only sixteen are original, the majority being those used by Tabernæmontanus in his *Icones* of 1590, which the printer, Norton, procured from Frankfort. Though based on Dodoens, the *Herball* contains descriptions of plants taken from De L'Ecluse and from L'Obel, together with some of Gerard's own discovery. For such of the latter as were rare, he gave the localities in England.

Gerard claimed for the *Herball* primarily a scientific purpose, but he included in it much contemporary folk-lore, some of which was largely legendary. His account, for instance, of the "Goose Tree, Barnacle Tree, or the Tree bearing Geese" runs as follows: "But what our eies have seene and handes have touched we shall declare." He then tells us that on an island in Lancashire, called the Pile of Foulders, there grows a curious tree which bears a fruit, which when ripe opens, and out drop substances, "which falling into the water do become fowles, which we call Barnacles, Brant Geese, or Tree Geese." At page 1587 he gave an illustrative engraving. He did not adhere to the six books of the *Pemptades*, but treated of the whole vegetable kingdom in three sections. "In three bookes as in three gardens, all our plants are bestowed." The first contains the grasses, grain, rushes, reeds, flags, and bulbous-rooted plants; the second, herbs used in diet, physic, or for ornament and pleasure; the third, trees, shrubs, fruit-bearing plants, rosins, gums, roses, heaths, mosses, mushrooms, and sea plants. "Each booke hath chapters, as for each herbe a bed." In these the several species are described with their place and time of flowering, names, and virtues.

"Mosses, mushrooms, and sea plants" form a sufficiently artless classification of the *Cryptogamia*. Nor, when one considers how little was known about these forms of life at so comparatively recent a date as the beginning of the last century, is one astonished at the inclusion of sponges and "corrall" among sea plants. "There be divers sorts of mosse growing as well within the bowels of the sea as upon the rocks," says Gerard of the Algæ. Interesting too, to the curious, is the realistic sketch, exactly coloured, of "Murcus ex cranio humano, Moss von todten Kopf, mosse growing upon the skull of a man," and the division of Fungi into "Fungi Vulgatissimi Esculenti, common mushrooms to be eaten," and Fungi Lethales, poisonous or deadly mushrooms.

Apart from its importance from the point of view of botany and of materia medica, the book may be considered as the first published in England that could be called a popular book on gardening especially adapted for the use of English gardeners, and in English gardens, and it was because of its popularity that Gerard obtained the title, which he still holds, of the Father of English gardening. The association of the garden, commonly spoken of as the physic garden, with the herbalists and their work. was necessarily a close one, for botanical exploration was but in its infancy, and nearly all the simples that were used in medicine were cultivated. There was little known of indigenous plants till late in the era of the herbalists, who accordingly relied on the garden as the source of supply. We have seen that the garden played a large part in Turner's work, as it did in Gerard's and later on in Parkinson's. Though certain parts of the country were investigated, botanical exploration was not systematic, and comparatively small progress in it was made till the time of Ray.

A specimen of the descriptions in Gerard's *Herball* may be quoted as illustrative of the diffuse botanical writing of the time. Selecting at random we have the following for *Geranium violaceum:* "The Cranesbill with violet coloured flouers hath a thicke wooddie roote, with some few strings annexed thereto: from which rise immediatly forth of the ground divers stiffe stalks, which divide themselves into other small branches, whereupon are set confusedly broad leaves, made of three leaves a piece, and those jagged or cut about the edges: the flouers grow at the top of the braunches of a perfect Violet colour, whereof it tooke his name: after which come such beakes or bils as the other of his kinde."

A good deal of controversy arose after the publication of the *Herball* as to the part which Gerard could claim in its authorship. His own account of the matter is contained in the Dedicatory Epistle and Introduction to the *Herball.* "To the large and singular furniture of this noble Island I have added from forreine places all the varietie of herbes and flouers that I might anyway obtaine, I have laboured with the soile to make it fit for plants, and with the plants that they might delight in the soile, that so they might live and prosper under our clymat, as in their native and proper countrey: what my successe hath beene and what my furniture is, I leave to the report of them that have seene your Lordship's gardens and the little plot of myne owne especiall care and husbandry. But because gardens are privat, and

many times finding an ignorant or a negligent successor, come soone to ruine, there be that have sollicited me, first by my pen, and after by the Presse, to make my Labors common, and to free them from the danger whereunto a garden is subject: wherein when I was overcome, and had brought this History or report of the nature of Plants to a just volume, and had made it (as the Reader may by comparison see) richer than former Herbals, I found no question unto whom I might dedicate my Labors. . . . I have here therefore set downe not onely the names of sundry Plants, but also their natures, their proportions and properties, their affects and effects, their increase and decrease, their flourishing and fading, their distinct varieties and severall qualities, as well of those which our own Countrey yeeldeth, as of others which I have fetched further, or drawne out by perusing divers Herbals set forth in other languages, wherein none of our countrymen hath to my knowledge taken any paines since that excellent Worke of Master Doctor Turner. After which time Master Lyte, a Worshipfull Gentleman translated Dodonœus out of French into English: and since that, Dr. Priest, one of our London Colledge, hath (as I heard) translated the last Edition of Dodonœus, and meant to publish the same; but being prevented by death, his translation likewise perished. Lastly my selfe, one of the least among many, have presumed to set forth unto the view of the world, the first fruits of these myne owne labors."

A very different version was given by L'Obel, between whom and Gerard relations became very strained after the publication of the *Herball*. He came at last to regard it as in a large measure a plundering of the *Adversaria*, and is said to have indignantly endorsed his former attestation of the *Catalogus*, "Haec esse falsissima attestator Matthias de L'Obel." In the preface to the *Illustrationes*, written about 1614, he appears to have expressed his opinion of Gerard in a very unfriendly way. Pulteney speaks of what he said as "very reprehensible" and accuses him of uncandid and disingenuous conduct towards Gerard, though while the latter was living, L'Obel had always appeared to be his friend, and had spoken and written of him in terms of eulogy, even writing a recommendatory letter which Gerard prefixed to the *Herball*. Before the appearance of the *Herball* he styled him "chirurgus et botanicus peroptimus." However, L'Obel's account of the preparation of the *Herball*, as taken from his animadversions on Rondeletius (1605), and from the *Illustrationes*, was that Gerard had become possessed of a translation of Dodoens'

Pemptades, which had been made by a certain Dr. Priest (referred to by Gerard as already quoted) at the request of Norton, the printer; that he then suppressed the authorship and passed the translation off as his own. L'Obel said that Gerard's classical attainments were not sufficient for him to have made the translation and disparaged his ability as a botanist. He made the statement, further, that when the first book of the *Herball* was in the press, only the part dealing with the grasses having been printed, a friend of his own, Garret by name, a botanist and apothecary, "a curious searcher of simples," pointed out to Norton some gross errors in the text, and added that Norton thereupon engaged him, L'Obel, to superintend or edit the work, which he claimed to have corrected "in a thousand places."

Whatever may have been the case with regard to the first accusation made by L'Obel there was some foundation for the second. The charge of inaccuracy was strongly repudiated by Gerard, who greatly resented Norton's action based upon it. He claimed that the work was "sufficiently correct," and added that "L'Obel had forgotten the English language."

L'Obel's account received some corroboration from Johnson, "the best herbalist of his age in England," when the latter enlarged and amended Gerard's *Herball* in 1633, as will appear later. He endorsed L'Obel's statement that Dr. Priest's translation of the *Pemptades* came into Gerard's hands at the translator's death, and said, "This translation became the ground-worke whereupon Mr. Gerard built up this worke; but that it may not appeare a translation he changes the generall method of Dodoens into that of L'Obel, and therein almost all over follows his *Icones* both in method and names, as you may plainly see in the Grasses and Orchids. To this translation he also added some plants out of Clusius (De L'Ecluse) and other some out of the *Adversaria* and some fourteene of his owne not before mentioned. . . . Divers chapters have scarce a word more or less than what is in him (Dodoens). I cannot commend my author for endeavouring to hide these things from us."

L'Obel's criticism of Gerard's classical attainments was also supported by Johnson, who commented severely on his want of learning. He accused him of frequent mistranslations, and of not being able to distinguish between "the antient and moderne writers"; also of having made many mistakes in arranging and referring to the figures of the *Herball* which were taken from Tabernæmontanus.

In strong contrast with these animadversions on Gerard, made by L'Obel in his later years, we have the estimation of two of his contemporaries whose opinions carried weight. The first of these, Baker, who was surgeon to the Queen, gave him unstinted praise. "Master Gerard hath taken more paines than ever Matthiolus did in his commentaries, and hath corrected a number of faults that he passed over, and I dare affirme that Gerard doth knowe a great number of simples that were not knowen in his day. Upon his proper cost and charges he hath had out of all parts of the world all the rare simples which by any means he could attain unto, not onely to have them brought, but hath procured by his excellent knowledge to have them growing in his garden, which as the time of year doth serve, may be seen; for there you shall see all manner of strange trees, herbes, rootes, plants, flowers, and other such rare things, that it would make a man wonder how one of his degree, not having the purse of a number, could ever accomplish the same. I protest upon my conscience, I do not think for the knowledge of plants that he is inferior to any, for I saw him tried with one of the best strangers that ever came into England, and was accounted in Paris the only man; and he being here, was desirous of going abroad with some of our herbalists, for the which I was the mean to bring them together, and one whole day we spent therein; searching the rarest simples; but when it came to the trial my Frenchman did not know one to his four." This Frenchman seems to have been M. Robin, herbalist to the King of France, whose knowledge of plants is commended in the *Herball*.

Bredwell also supported Gerard's claim to originality. "Many things," he said, "hath he nourished in his garden and observed in our English fieldes that never came in their (former writers) pens to write of. Againe, the greatest number of these plants, having never beene written of in the English toong, would have wanted names for the vulgar sort to call them by, in which defect he hath beene curiously careful, touching both old and new names to make supplie, and lest the reader should too often languish with frustrate desire, to finde some plant he readeth of rare vertue, he spareth not to tell, if himselfe have seene it in England, in what wood, pasture or ditch the same may be seene and gathered."

Johnson

The third of the succession of great English herbalists was Thomas Johnson, like Gerard an eminent medical man, but

attached to the lower branch of the profession—the apothecaries, of whose company he was a member. The date of his birth does not seem to have been preserved, but it took place at Selby in Yorkshire. We find him carrying on his business in Snow Hill, London, in 1629. Like Gerard he had a physic garden of his own at his place of residence, but unlike him he did not depend upon it so much for his supply of plants for study and professional employment, for he was an ardent field botanist, and devoted much time to botanical investigations in the field. At about this time the Apothecaries' Company instituted what were called "herborizing" excursions, of which more will be said in another connection. These were really sincere, though somewhat crude, investigations of the native flora of particular districts and were carried out with considerable regularity. We may look upon them, indeed, as the first systematised efforts in the direction of botanical surveys. Johnson threw himself with much zeal into this department of work and study, and soon, Gerard by this time being dead, he gained the reputation of being the foremost herbalist of his time in England.

Unhappily for science he did not escape the embroilment of the Civil War; he fought with considerable distinction on the side of the King, and reached the rank of lieutenant-colonel. In a skirmish at Basing on September 14, 1644, he was wounded in the shoulder and died of his injuries after lingering for a fortnight. It was said of him, "At which time his worth did justly challenge funeral tears; being then no less eminent in the garrison for his valour and conduct as a soldier, than famous through the kingdom for his excellency as an herbalist and physician."

Though his life was thus unhappily cut short, Johnson left his mark upon his age as a writer and a botanist. As we have seen, he devoted himself more than any of his predecessors to work in the field. He studied the plants of Kent and those in the neighbourhood of London, and carried out, as Ray did later, many botanical journeys to study the local floras. He was probably the first botanist to travel through Wales: at any rate, he made an extended excursion there, in the course of which he visited Snowdon, and discovered among other plants *Papaver cambricum*, *Serratula alpina* and *Rhodiola rosea*.

His first publication was a local flora of Kent, which appeared in 1629, under the title of *Iter in Agrum Cantianum*. Three years later he brought out another similar work, *Ericetum Hampstedianum*, and in 1634 he published a third, dealing with a journey

through Oxford to Bath and Bristol and back by Southampton, the Isle of Wight, and part of Surrey, an excursion which lasted twelve days. In this book, which he called *Mercurius Botanicus; sive Plantarum gratia suscepti Itineris, Anno* 1634 *Descriptio; cum earum Nominibus Latinis et Anglicis*, he described more than 600 plants, several of which were quite new to English botany. In 1641 appeared the results of his trip to Wales under the title, *Pars Altera, sive Plantarum gratia suscepti Itineris in Cambriam.*

But apart from these local floras, Johnson achieved his greatest success by enlarging and re-editing Gerard's *Herball*, a task he completed in 1633. Some thirty-six years had elapsed since it was written, and though things moved but slowly in the seventeenth century, a good deal of progress had been made in the interval. Explorations were becoming more common than they had been; the work done was much more systematic, and search for new plants was more thorough. New works had been written by many of the German botanists; in particular the *Prodromus* of K. Bauhin had appeared in 1620, and the *Pinax* in 1623. The latter work had already begun to simplify study by gathering together so much of what had previously to be looked for through the writings of many authors. Johnson was well qualified to write a new work, being a sound scholar and familiar with the classical as well as the modern languages of science. Instead, however, of starting again at the beginning and writing a book to replace Gerard's, he was content to take the *Herball* of the latter as his basis of operations, as Gerard had done the *Pemptades*, presenting the result of his labours with much generosity as his predecessor's *Herball* amended by himself. Such was his energy and application that he completed his task in a single year.

The book appeared under the title of "The Herball, or General Historie of Plantes. Gathered by John Gerarde of London, Master in Chirurgerie. Very much enlarged and amended by Thomas Johnson, citizen and apothecarye of London." It was justly styled "enlarged and amended," for it was enriched with descriptions of more than 800 plants that were unknown to Gerard, and it was illustrated by more than 700 new figures, which raised the total number of woodcuts to 2717. In it the author made innumerable corrections in Gerard's work. In a second edition published in 1636, Johnson held out hopes of publishing later an appendix which should contain the results of his own actual and prospective botanical journeys, but the idea was never carried out, and his own investigations were set out only in the local floras to which allusion

has been made, some of which only were of later date. In an introduction or preface to the first edition Johnson wrote a short historical account of the leading writers prior to his time, and set forth, at its conclusion, a statement of what he claimed to be original in the amended *Herball*.

The work so enlarged contained about 2850 descriptions of plants, the largest number so far included in any herbal. It made the book the most important and influential of the time, and for long afterwards Ray gave it the name of "Gerard Emaculatus," while Haller wrote of it "dignum opus, et totius rei herbariæ eo ævo notæ, compendium."

The rapidity with which Johnson worked is the more remarkable as he had but little assistance. His chief helper seems to have been Goodyer, to whom he alludes in the preface as "the only assistant I had in this werke, from whom I received many accurate descriptions, and some other observations concerning plants, the which (desirous to give every man his due) I have caused to be so printed as they may be distinguished from the rest." Goodyer is referred to in Parkinson's *Herball*, which came out a few years later, as a "great lover and searcher of plants . . ." who "hath found in our country many other plants not imagined to grow in our land."

Johnson appears to have been acquainted with Tradescant the elder, the famous gardener to Charles I., and to have been on terms of friendly intimacy with Parkinson, his great contemporary herbalist.

The *Herball* of Gerard, and its enlargement by Johnson, though they were the most notable works of the time, did little to advance the development of botanical science. They were catalogues of plants, and contributed substantially to the knowledge of those indigenous to Britain in particular, but they may be in a way compared to a dictionary rather than to any other form of work. They were not free from much that was fanciful and far from scientific, dealing with folk-lore, and with superstitions as to medicinal virtues, which were attributed to particular plants. Moreover they were founded on no well-defined system, and paid little heed to natural affinities, while they knew nothing of relationships of descent. The time for this had not yet come.

The general style of Johnson's work differs hardly at all from Gerard's; the descriptions are very chatty and gossipy; he gives all particulars which he has gathered from other writers, both ancient and modern, with their views as to identity with other writers'

plants; he discusses their medicinal properties or *vertues,* and quotes the opinions of the older writers on these points with great completeness. It is interesting to notice a discussion of a curious fallacy which interested agriculturists in the middle of the nineteenth century, and excited some controversy then in the eastern counties. " I thinke it a very fit thing to adde in this place a rare observation of the transmutation of one species into another in plants, which though it have beene observed of antient times as by Theophrastus (de caus. plant. lib 3, cap 6), whereas amongst others hee mentioneth the change of spelt into oates; and by Virgill in these verses:—

> Grandia sæpe quibus mandaminus Hordia sulcis
> Infelix Lolium et steriles dominantur avenæ.

that is

> In furrowes where great Barley we did sow
> Nothing but darnel and poore oates do grow.

Yet none that I have read have observed that two seuerall graines, perfect in each respect, did grow at any time in any one case; the which I saw this yeare 1632, in an eare of white wheat, which was found by my good Friend Master John Goodyer, a man second to none in his industrie and searching of plants nor in his judgement or knowledge of them. This eare of wheat was as large and faire as most are, and about the middle thereof grew three or foure perfect oats in all respects, which being hard to be found I hold very worthy of setting downe, for some reasons not to be insisted upon in this place."

This seems to point to the author as being somewhat credulous; on the other hand, he throws considerable scorn on the legend of the mandrake.

CHAPTER V

THE AGE OF THE HERBALISTS—*continued*

Parkinson

ANOTHER notable figure comes into our field of view before the departure of all those concerned in the production of Gerard's *Herball.* This was John Parkinson, florist, apothecary, and herbalist. He was born in 1567, and was consequently a man of thirty when Gerard's book saw its first edition. He lived till 1650, the year of the appearance of John Bauhin's *Historia Plantarum Universalis*, when Ray was twenty-two years old, and the age of the herbalists was practically ended. Little is known of his life, which seems to have been spent tranquilly in the contemplation of Nature, the practice of gardening and the study of materia medica, and in the accumulation and massing of the material for his two great works. He bore a very high reputation among his contemporaries, alike for his skill in his profession and for his knowledge of plants. The former was indicated by his being appointed apothecary to James I., while Charles I. gave him the title of Botanicus Regius Primarius, the latter was recognised by the leading physicians of the day, Dr. Clayton, Regius Professor of Physic at Oxford, speaking of him as "England's chiefest herbalist."

Parkinson seems to have been a man of simple, devout nature, for he starts his *Paradisus* with an expression of thankfulness to God for giving the world in general, and himself in particular, such good and beautiful gifts as gardens, flowers, and fruit. His writings are full of literary charm, and show him to have been possessed of acute observation and considerable originality; he is always clear if not concise, and his well-chosen words leave his readers in no doubt as to his meaning. He evidently had a vein of humour in his constitution, for he gave his first book a title, *Paradisus in sole*, which is a pun upon his own name, Park-in-sun.

He did not, however, claim so much to be a botanist as a gardener and a florist. In this field he had few predecessors, and these of no great eminence. Apparently the earliest was Hill, whose *Profytable Art of Gardening* was printed in 1574: Platt's *Garden of Eden* was published in 1600. Both passed through

several editions, but neither of these works can properly be compared with that of Parkinson. Nor among his successors was his equal found till the time of Miller.

The publication to which, in the first instance, Parkinson owed his fame was the famous *Paradisus*, which appeared in 1629, four years before Johnson's edition of Gerard's *Herball*. It was based upon the contents of his own garden, which was well stored with rarities, and was commended by both L'Obel and Johnson. It was very practical from the point of view of a gardener, containing excellent cultural directions both for flowers and fruit. Its title in full was, "Paradisi in sole, Paradisus terrestris: or a garden of all sorts of pleasant flowers which our English ayre will permitt to be noursed vp, with a kitchen garden of all manner of herbes, rootes, and fruites, for meate or sause, vsed with vs, and an orchard of all sorte of fruitbearing trees and shrubbes fit for our land; together with the right orderinge, planting, and preseruing of them, and their vses and vertues. Collected by John Parkinson Apothecary of London 1629." In the work nearly 1000 plants are described, and 780 of them figured. Few native plants are found there, for the principal productions of the English gardens were then, as now, exotics. They included, chiefly, the continental flowers, with a sprinkling from Asia and North Africa, and certain species from Virginia and a few other American localities.

Parkinson attempted to bring into relation with the flower-garden the principles underlying the herbals. As we have seen, hardly any traces of what we now know as natural systematic relations had found their way into these writings, though a beginning of a sort had been made by L'Obel. In the garden not even so much as this was seen. Even L'Obel did little more than introduce the idea of system, and it remained for a later age to bring it into fuller notice. The *Paradisus*, dealing thus with the flower-garden only, makes very slight appeal to the botanist, but it gives us a very complete picture of the English garden at the beginning of the seventeenth century. The book has for its frontispiece a representation of the Garden of Eden, among the flowers of which the cactus, lily, sunflower, and tulip are clearly recognisable. Its arrangement follows the lines indicated in the title, but, copying Gerard, after the description of each species are given its place, time of flowering, synonyms, and virtues. The figures, many of which are copied from De L'Ecluse and De L'Obel, were cut in England for this work, and are far inferior in execution to those of Gerard's *Herball*.

The *Paradisus* begins by discussing situation, aspect, and soil, and passes on to deal with the most advantageous way of designing the beds and the walks, of constructing borders, and of the actual cultivation. Parkinson pronounces in favour of "squares, knots, and trayles," walks both open and close, with such additions, where possible, as a maze or a wilderness; he advocates the employment of rock-work in suitable places, and the construction of fountains for irrigation, with arbours in convenient spots, "both graceful and necessary for shadow and rest." He leads his reader through his garden of pleasure, shows him the "diuers Outlandish flowers that for their pride, beauty, and earlinesse" are to be planted in gardens of pleasure for delight, and tells him their "nature, names and vertues," and their native countries. The descriptions of the separate plants are detailed and somewhat verbose. Let us take, for instance, his account of *Iris cærulea versicolor* which runs as follows:—

"This purty coloured Flowerdeluce hath his leaves of the same largenesse, with the lesser variable purple Flowerdeluce last described, and his flowers diversly marked: for some have the fols blew at the edges, and whitish at the bottome, the arched leaves of a yellowish white, and the upright leaves of a whitish blew, with yellowish edges. Some againe are of a darker blew, with brownish spots on them. And some are so pale a blew, that we may call it an ash-colour: And lastly, there is another of this sort, whose upright leaves are of a faire pale blew, with yellowish edges, and the falling leaves parted into two colours, sometimes equally in the halfe, each side sutable to the other in colour: And sometimes having the one leafe in that manner: And sometimes but with a divers coloured list in them: in the other parts both of flower and leafe, like unto the other."

He treats of garden flowers in 134 chapters, the kitchen-garden occupies 63, while 24 only are devoted to fruit trees and shrubs. He seems to have been acquainted with 120 varieties of tulip, 60 anemones, 50 hyacinths, 50 carnations, 20 pinks, and more than 40 irises. In the orchard he speaks of "60 kinds of plums, as many apples and pears, thirty cherries, and more than 20 peaches."

The *Paradisus* was dedicated to Queen Henrietta Maria, and its appreciation by the King was shown by its author being appointed Botanicus Regius Primarius, as we have already mentioned.

While Parkinson's reputation was established by the appearance of the *Paradisus*, the latter was overshadowed eleven years later

by the publication in 1640 of what was his much greater work, the *Theatre of Plants.* He intended to supplement the *Paradisus* with a treatise on medicinal herbs under the title of *A Physical Garden of Simples*, but with " the revolution of time," as he quaintly says, he " changed the note (from this title to a ' Theatre of plants ') yet not the nature." This new work, whose preparation had occupied him for so many years, was intended at the outset to have been a handbook of materia medica, almost a Pharmacopœia, and to have contained accordingly only the medicinal herbs. The delay in its appearance is attributed " to the disastrous times " and other hindrances, which caused repeated postponements. As time went on the original plan was given up, and he essayed the presentation of the position of botanical science of the time. With a quaint conceit he spoke of it in the preface as " the Manlike worke of Herbes and Plantes," which he set out to treat of " as I formerly did a Feminine of Flowers." How little advance had been made in botanical science since even the time of Theophrastus appears from what he says upon the question of sex in plants when treating of the palm tree. " The date is the fruit of this tree; the best kinds are called *regiæ* as being diet fit for Kings. The antient writers have set down many things of the date tree, that here are male and female, and that to make them bear they must be near each other, or else they will not bear; but I pray you account this among the rest of their fables."

The volume is a thick closely printed folio, whose title page, besides the figures of Adam (with his spade) and Solomon, contains a small portrait of Parkinson. The title runs: " Theatrum Botanicum; or Theatre of Plants, or an Herball of a large extent: Containing therein a more ample and exact History and declaration of the physical Herbes and Plants that are in other Authors; encreased by the access of many hundreds of new, rare, and strange Plants from all parts of the world; with sundry gummes, and other physical materials, than hath been hitherto published by any before; and a most large demonstration of their nature and vertues. Shewing withal the many errors, differences and oversights of sundry authors that have formerly written of them, and a certayn confidence, or most probable conjecture of the true and genuine Herbes and Plants; Distributed into sundrie Classes or Tribes, for the more easy knowledge of the many Herbes of one nature and property, with the chief notes of Dr. L'Obel, Dr. Bonham and others inserted therein. Collected by the many yeares travaile, industry and experience in this subject

of John Parkinson, Apothecary of London and the King's Herbarist."

This digest attempted the description of nearly 4000 plants, almost 1000 more than were contained in Johnson's *Gerard*. The descriptions in many instances were new, and great care was exercised to secure accuracy in indicating localities. In the enumeration of the synonyms the author incorporated the valuable work of K. Bauhin's *Pinax*, and in many cases verified them by reference to the original authors. In dealing with the medicinal peculiarities of the plants he quoted largely from the more exclusively galenical works of the time, the writings of De L'Ecluse, Orta, à Costa, Monardes, and others. He discussed also the opinions of Greek, Roman, and Arabian physicians, and took the greatest care to render his account as complete as the general state of knowledge would permit.

The illustrations, like those of the *Paradisus*, were very inferior in execution to those of Gerard, which, borrowed from the *Herball* of Tabernæmontanus, were cut at Frankfort.

In arrangement Parkinson's *Herball* is confused and purely empirical, being avowedly founded on the known or supposed qualities and virtues of the plants described. He makes seventeen tribes: (i.) *Plantæ odoratæ*, sweet-smelling plants; (ii.) *Catharticæ*, purging plants; (iii.) *Venenatæ, Narcoticæ et Alexipharmacæ*, venomous, sleepy, and hurtful plants, and their counter poisons; (iv.) *Saxifragæ*, saxifrages or break-stone plants; (v.) *Vulnerariæ*, wound herbs; (vi.) *Refrigerantes et Intubaceæ*, cooling and succory-like herbs; (vii.) *Callidæ et Acres*, hot and sharp biting plants; (viii.) *Umbelliferæ*, umbelliferous; (ix.) *Cardui et Spinosæ*, thistles and thorny plants; (x.) *Filices et Herbæ capillares*, ferns and capillary herbs; (xi.) *Legumina*, pulses; (xii.) *Cercalia*, corn; (xiii.) *Gramina, Junci, Arundines*, grasses, rushes and reeds; (xiv.) *Paludosæ, Aquaticæ, Marinæ, Musci et Fungi*, marsh, water and sea plants, mosses, and mushrooms; (xv.) *Miscellaneæ*, the unordered tribe; (xvi.) *Arbores et Frutices*, trees and shrubs; (xvii.) *Exorticæ et Peregrinæ*, outlandish plants.

This heterogeneous medley, founded sometimes on medicinal qualities, sometimes on habitat, sometimes on apparent botanical differences, shows how little progress was made in classification by the herbalists. Gerard and Parkinson both failed to carry forward the crude attempts of L'Obel; indeed, they did not even maintain the advance he made. The evils of such a classification are quaintly shown by Parkinson's own naïve comment on Class xv., the un-

ordered tribe: " In this tribe as in a gathering Campe I must take up all those straglers that have either lost their rankes, or were not placed in some of the foregoing Orders, that so I may preserve them from losse and apply them to some convenient service for the Worke." We get thus grouped together among others the stitchwort, eyebright, milkwort, columbine, orchis, and liverwort. In Class xiv. among his Mosses he includes true mosses, sundry small ferns, cup fungi, Lycopodium, Selaginella, and some cypresses, while the liverworts, nearest allies to the mosses, he puts in Group xv. The Marinæ include the lichens with the Algæ or sea-weeds.

The absence of any true line of discrimination between species and variety, the helpless groping after some indication of affinity, the confusion arising from the absence of any valid theory of relationship show the impossible position which the herbalists took up. They failed utterly, partly from non-recognition of the functions of the flower, partly from the consequent absence of any breadth of view, and tied themselves up in incoherent details of no value. A single example may suffice: Pulteney says, " The sea-cabbage (*Brassica orientalis*) a *siliquose* (cruciferous) plant is entitled by Gerard and Johnson, as well as by Parkinson, even contrary to the examples of Clusius and Dodonœus, under the same generical name with the thorow wax (*bupleurum*) an *umbelliferous* plant, merely because the leaf is of the *perfoliate* kind."

Langham

Mention may be made here of a small herbal published by Langham in 1633. It was of little value, being a catalogue of plants used in medicine at the time, and was more medical than botanical. It was printed in English, but was in black letter.

CHAPTER VI

THE AGE OF THE HERBALISTS—*continued*

Bobart the Elder and the Oxford Botanic Garden

DURING the period which we have been examining, it has not been difficult to notice the dependence of the herbalists upon their so-called physic gardens. In several instances an author's first publication was a catalogue of what was growing in the garden with which he was connected, either his own or one put in his charge by some wealthy patron. The plants included in such catalogues did not show any attempt at discrimination between indigenous and exotic, so that they were in no sense what we now understand as floras. Nor were the gardens in England public institutions, even when they were not the private property of the herbalist himself. During the latter part of the sixteenth century public gardens began to be founded in certain parts of France and Italy, but nothing of the kind was met with in England till towards the end of the period of the herbalists. In 1621, however, Henry Danvers, Earl of Danby, who had been a gentleman commoner of Christchurch, Oxford, presented to that University, for the general advancement of learning, and especially that of physic, " a spacious illustrious physicke garden," situated " without the east gate of Oxford, near the river Cherwell, which was then meadow-ground, and had in ancient time been a cemetery for the Jews of Oxon." He made a gift of £250 to enable the University to purchase this spot, and therewith they bought out the lease of the person then in occupation, one Humphrey Ellis, and obtained a new one from Magdalen College, agreeing to pay an annual rent of forty shillings for the plot. The ground was then protected from the river by the introduction of fresh soil, and in due course enclosed with a wall. The garden was opened with some ceremony on July 25, 1621. The direct lease from Magdalen College was dated three days later, and articles between Lord Danby and the other parties to the foundation were drawn up and signed on November 6 following. On St. James's Day, 1632, the Vice-Chancellor went in procession to the garden, and laid the foundation stone of a new arched gateway, the greater part of the

ground having been walled in, under the direction of Inigo Jones. An oration was spoken on the occasion by Dr. Clayton, the King's Professor of Medicine. Both gateway and wall were finished in 1633. The Earl not only gave the ground, five acres in extent, but built greenhouses and stores, together with a residence for the superintendent, and endowed the establishment. The stocking and other expenses of laying out the garden amounted to upwards of £5000. There has been some misunderstanding about the date of this munificent presentation which has been ascribed to the year 1632, this being inscribed upon the great gateway. There is reason, however, for thinking that this date alludes to the erection of the gateway which took place a few years later than the establishment of the garden.

John Tradescant, who himself owned a physic garden at Lambeth, has been said to have been appointed the first gardener of this nursery of simples, but he probably never took up the post. In 1640 we find Dr. Clayton, in an address prefixed to the beginning of Parkinson's *Theatre of Plants*, saying that the garden was then "compleately beautifully walled and gated." He adds, "The furnishing and enriching thereof with all usefull delightfull plants will the better be expedited by your painefull happy satisfying work."

This was the earliest public botanic garden to be established in England, and it was not without considerable influence on the development of the science. As we shall see in connection with other foundations of a similar kind, the botanic gardens served as centres of study and research, much as have done the botanic laboratories in the nineteenth century. They gathered round them a succession of eminent men, whose labours, in the absence of such institutions, would have lost coherence and influence.

The object of this foundation at Oxford was "for a nursery of Simples, and that a Professor of Botanicey should read there, and show the use and virtue of them to his auditors." The settlement, however, of such a professor was not immediately carried out. Wood, the Oxford annalist, says on this matter, "The Earl, though he had settled a gardener, John Tredesken, Senior, deferred it from time to time, especially for this reason that the garden could not be soon enough furnished with Simples and they with a maturity. At length distempers breaking forth, and the Earl dying soon after, nothing was done as to that, save only by his will, dated December 14, 1640, which was three years before he died, he appointed certain persons to settle by legal conveyance

to the University the Rectory of Kirkdale in Yorkshire, for the use of the said garden. Afterward Sir John Danvers, his brother, in pursuance of the will, did settle it on the University to the end that with the revenues thereof the garden be repaired, and a stipend be paid to the Professor and gardener. But so it was that the times were unsettled, and the revenues falling shorter than was expected, nothing was done in order to this settling of a Professor till an. 1669."

The garden when established and endowed appears to have been placed by the earl under the superintendence of Jacob Bobart the Elder, though it does not appear clear what were the relative positions of Bobart and Tradescant, if the latter, indeed, was ever in office there. Bobart was born in 1599, in Brunswick. His appointment was a residential one, and we find him occupying a house in the garden till his death in 1680. He appears to have been a skilful gardener, and to have succeeded in laying out the space at his disposal to the greatest advantage, copying various natural features by artificial construction. Sharrock, in his *Improvement of the Art of Gardening* (1694), says, "The artificial bog is made by digging a hole in any stiff clay, and filling it with earth taken from a bog. . . . Of this sort in our garden here in Oxford, we have one artificially made by Bobart, for the preservation of boggy plants, where, being sometimes watered, they thrive for a year or two as well as in their natural places."

In 1648 Bobart published a list of the plants in the garden under the title of "Catalogus Plantarum Horti Medici, Oxoniensis Latino-anglicus et Anglico-latinus: alphabetico ordine." The plants in this little duodecimo of 105 pages are barely enumerated, without synonyms or references to any author, and the number of English species given amounts to about 600. In the preface it is stated that the garden contained 1600 species, but in this number were included both exotic and indigenous plants, including varieties of each. A greatly improved edition of the book was published in 1658 under the joint authorship of Bobart and his son, Dr. William Stephens, Principal of Magdalen Hall, and William Browne, senior fellow of Magdalen, the latter, according to Wood, taking the chief part in its preparation. The specific names given by Gerard and Parkinson to each plant are adopted by the authors of this *Catalogue*, who quote the page of the works under the authority of the "Hortus Eystettensis." Pulteney says of it, "There are many dubious and ill-ascertained plants in this Catalogue; and those marked as new are almost wholly varieties.

English Botany seems to have received little or no accession by it; and I am not aware of one indigenous plant first mentioned in this list."

Tradescant

During this period there were living in England two men who call for notice partly on account of their possible connection with the Oxford school, though they cannot be said to have aided very materially the growth of botanical science. These were the Tradescants, father and son, conspicuous figures of the time, friends and correspondents of Gerard, Johnson, and Parkinson. The association of the elder Tradescant with the Oxford garden has been alluded to. He was living in England soon after 1620, and was apparently gardener to Queen Henrietta Maria. He is said to have claimed as his patrons the Earl of Salisbury, Lord High Treasurer, Lord Wootton, and the Duke of Buckingham, so that he was well known at court. Not a great writer, but a traveller, he was a friend and correspondent of Robin of Paris, who figures among the friends of Morison, the first Oxford Professor of Botany. He journeyed to Northern Russia and his account of the visit he paid there gave the earliest account of the plants of that country; of these he enumerated some two dozen wild species that came under his own observation. He also visited Algiers, and Parkinson tells us he brought back with him the Algerian apricot. In 1672 he went with the expedition of the Duke of Buckingham against La Rochelle. He is said to have introduced several Mediterranean plants into England. After the death of Buckingham he entered the Royal service, and obtained the title of King's Gardener. Tradescant is thought to have died in 1638, but there is some uncertainty about the date. He is chiefly known on account of his having founded a museum of objects of natural history in Lambeth, which was known as Tradescant's Ark. Elias Ashmole, who founded the museum at Oxford, was one of his friends, and added many varieties to the Lambeth collection.

Tradescant was succeeded as Queen's Gardener by his son John, born in 1608, himself a great traveller. Little is known of him that is important from our point of view, save that he published a *Catalogue* of his museum in 1656, and on his death, in 1662, gave its contents to Ashmole, so that it became absorbed in the Ashmolean Museum at Oxford.

It is worth noting that the Tradescants introduced into England the lilac, the acacia, and the occidental plane, besides other less popular plants.

How

It will have been noticed that the apparent aim of the older herbalists was to procure as full a list of plants as possible, and to show their bearing on medicine. Botany, in the scientific sense, was consequently a secondary object with them. Whether in its distribution a plant was exotic or indigenous mattered to them little or nothing. It is difficult, therefore, to speak of British botany, or the British flora, for the idea of restricting botany in any sense by using territorial terms had not so far dawned. With the next of the herbalists, William How, we get the first indication of such delimitation of the science. How wrote a *Phytologia Britannica*, which was published soon after the Oxford Movement had become established.

How was born in 1619, and received his education at Oxford, being a member of St. John's College. He graduated as M.A. in 1645, and afterwards practised as a physician in London. He did not escape the excitement of the time, but took part in the Civil War, fighting on the side of the King; he reached the rank of captain in the cavalry. On the conclusion of the war he settled down to his practice, but occupied part of his leisure in the preparation of his herbal, which appeared anonymously in 1650, under the title of "Phytologia Britannica, natales exhibens indigenarum Stirpium sponte emergentium." It was a small duodecimo volume of 133 pages. How died in 1656.

This publication marks the development of the departure which Johnson made from the practice of the older writers in relying on their gardens for the plants they described, and which became much more extensively followed after Ray had pushed forward the idea of systematic classification. In preparation for it, exploration of the country and search for its peculiar plants was for the first time seriously attempted, so that it may be regarded as the first English flora. It contained the record of 1220 plants, the descriptions of many being copied from Johnson's record of his own travels published in the *Mercurius*, but many being original. Probably How took but little personal share in the expeditions or explorations on which these were founded, for he seems not to have been an enthusiastic traveller or botaniser, but he had a circle of very ardent friends, who sent him lists of

plants which they had found and described. The chief of these were Stonehouse, a native of Yorkshire, Goodyer, the correspondent of Gerard, and Johnson, Bowles, and Heaton. Bowles resided in Kent; he was an ardent botanist and explorer of new plants. He spent some time in Wales, and was associated with Johnson in his "simpling" excursions. This little band of pioneers did good service in working out a basis for the British flora proper. Not that they were always successful, for Ray pointed to descriptions of more than thirty species which were not indigenous, some of which must have been mere garden escapes, or included by mistake or error of judgment. Others must have been incorrectly named as they could not afterwards be found in the places How had indicated.

Though the list comprises only 1220 plants, yet since the cryptogams are practically excluded, the catalogue is for the time a copious one. The arrangement is alphabetical in the order of the Latin names, which are followed by one or two synonyms, both from Continental and standard English writers. Then come the place of growth and minute descriptions of the particular spots where the rarities are to be found. There is a good deal of looseness of nomenclature, as in "*Gramen caninum supinum longissimum nondum descriptum*. The injury of the grass some nine miles from Salisbury by Mr. Tuckers, at Maddington, wherewith they fat hogges, and which is four-and-twenty foot long, which may happily be a kinde of *Gramen caninum supinum*, though Gerard English it ill Upright Dogge's Grass"; and again, "*Gramen caninum supinum alterum*, another sea-dogge's grass."

The *Phytologia* abounds in curious observations, as where Dr. Bowles remarks with reference to the spider orchis, *Orchis arachnitis*, "A brave plant and flowers betimes. I was much taken having never seen it before; it grows upon an old stone-pit ground which is now green, hard by Walcot, a mile from Barneck, as fine a place for variety of rare plants as ever I beheld."

How's last botanical work was to edit the manuscript of part of the *Illustrationes* of L'Obel, which had come into his hands, and which he published in 1655. It is much to be regretted that he made this the opportunity of attacking Parkinson with quite unworthy virulence. Pulteney says of it, "The notes which the editor has affixed would almost persuade the reader that he had published the work with a view to take an invidious retrospect of Parkinson's 'Theatre.' In the preface to the Phytologia and in that of this work, both written in a flowery and bombast style, as

well as throughout the notes, he speaks of Parkinson in very contemptuous language, and represents him as having made L'Obel's observations his own without acknowledgment. Whatever may have been the case in particular instances the attack on the whole was uncandid, since Parkinson in the very title of his 'Theatre' professes to have made use of, and inserted Dr. L'Obel's notes together with those of Dr. Bonham and others. In fact there is a petulance and an acrimony in the stile both of the author and of the editor of this work, which howsoever exampled in the last age is happily much less frequently the language of literature in the present."

Merret

The *Phytologia* obtained a fair repute among botanists, and had a good circulation for some years, but it does not appear to have been issued in a second edition. Eleven years after the death of its author the need of a work to take its place led to the appearance, in 1667, of the last of the herbals published before the rise of system under Ray. This was Dr. Merret's "Pinax rerum Naturalium Britannicum, continens Vegetabilia, Animalia et Fossilia in hâc insula reperta," a more ambitious work than the *Phytologia*, but not prepared with so much care, nor possessing so great merit.

Its author was born in 1616, and was educated, like How, at Oxford, being a member in succession of Gloucester Hall and of Oriel College. He was created a Doctor of Physic in 1642, and practised as a physician in London till his death in 1695. He was one of the original Fellows of the Royal Society.

This *Pinax* enumerates upwards of 1400 species of English plants, treated on the lines of the *Phytologia*, but the list is open to all the criticisms passed upon the latter; indeed, Ray held it to be less accurate, and spoke of it as "Merret's bungling Pinax." He "purposely omitted quoting it that he might avoid that censure of it which could not properly have been withheld, had he given his impartial opinion of that performance." The plants described were derived partly from the *Phytologia*, but Merret obtained many new records through the researches of Thomas Willisel, whom he engaged to search for plants in different parts of England, and who was so employed for five years. Willisel afterwards accompanied Ray on one of his botanising tours, and was employed in similar work by both Morison and Sherard.

Merret was aided also by his son in exploration, and had access to Goodyer's manuscripts. He therefore acted rather as editor than author of the *Pinax*, and being only superficially familiar with botany was not very successful in his treatment of the subject. The arrangement of the *Phytologia* was followed, but at the end there was a rude attempt made at a classification, somewhat on the lines of John Bauhin's *History*. An appendix dealt with the time and duration of flowering of each species named.

Besides writing the *Pinax*, Merret made some experiments on the problems of vegetable physiology, a subject at that time altogether unexplored. He investigated certain phenomena connected with the exhalation of water by succulent leaves and fruits, and upon the recovery of plants from wounds. These experiments, though for the time not deficient in ingenuity, can hardly be said to have contributed much to accurate knowledge.

CHAPTER VII

THE AGE OF THE HERBALISTS—*continued*

The Astrologists

WITH Merret the age of the herbalists may be considered to have ended. The age of empiricism was about to give way to something more scientific; the dawn of system was at hand, the new era, which was heralded by the labours of the greatest botanist who had so far appeared—the illustrious Ray.

Though from the nature of things but little accurate scientific work could be done under the conditions which existed, a comparison of the successive herbals which we have briefly noticed shows us that some advance was made. More plants were known, descriptions were becoming more accurate if more verbose, folklore was gradually cast aside, and some aspirations towards systematic arrangement were indulged in. Distinction began to be drawn between indigenous and exotic plants, and exploration of the country for the former was begun. The figures of the plants gradually became more numerous and, on the whole, more accurate, though perhaps the best of the period were those which came from the blocks first cut by Plantin for L'Obel, and used later by Gerard. Synonyms were more fully elucidated, so that there was less difficulty in comparing the writings of different authors. The gradual establishment of gardens, both public and private, led to more intimate acquaintance with the plants, and to familiarity with a larger number. The botanical excursion, beginning with the recreation of "simpling," became more widely popular, though it was no new thing, for we read of Penny, among others, searching for plants in Gesner's time. The medicinal properties of plants or simples became gradually more closely and clearly defined, and superstitions as to the way to gather them and to compound remedies, by degrees, gave place to more sensible views.

Another trend of thought gradually became clear; herbals gave place to floras, and the latter became a little more systematised; the distinction of plants into indigenous and exotic began to point to the recognition of national and local floras, the latter in par-

ticular being much extended by the more systematic exploration of the country. Especially important was the dawning of the appreciation of the need of system in classification. The tentative efforts made particularly by L'Obel gave an indication of growing dissatisfaction with mere cataloguing of names.

It is strange to find that side by side with this modest progress the influence of the old astrological speculation still held its own in many quarters. It was maintained largely by the credulity and superstition of the uneducated, who were preyed upon by dishonest quacks, and it certainly was not dispersed at the end of this period. In 1550, at the beginning of the era, Ascham's *Lyttel Herball*, to which reference has already been made, had on its title page the sentence, " with certayne additions at the end of the boke, declaryng what herbes hath influence of certayne starres and constellations, whereby may be chosen the best and most lucky times and days of their ministration, according to the moon being in the signes of heaven, the which is daily appointed in the Almanack."

We can notice a succession of these adherents of astrology side by side with the scientific writers whom we have mentioned. In 1567 appeared a little book by Maplet, called " A green forest, or a natural history, wherein may be seen the soveraign vertues of all kinds of stones and metals, herbs, trees, beasts, fowls, and fishes "—part of which was " the second Booke of the Aegemonie or chiefest vertues in all the whole kinde of Plants." Maplet's other writings savour still more highly of astrological leanings. Another herbal, written by Culpepper, was the most noted of this class. It was published in 1652, and was a very popular book among the less scientific people for more than a century. One Robert Lovell wrote another, of considerable size, about 750 pages, which was originally published in 1659, and ran through two editions, the second appearing at Oxford in 1665. This work, though having an astrological bias, showed on the whole a nearer approximation than most to the standard writings of the time, though its astrological bias made later readers " regret," as Pulteney says, " the misapplication of talents which demonstrate an extensive knowledge of books, a wonderful industry in the collection of his materials, and not less judgment in the arrangement."

Two more works appeared before the close of the century: one in 1664, written by Robert Turner, who called himself " Botanologiæ Studiosus," the other, in 1694, from the pen of John Peechey.

Even at the end of the century the influence of astrology had not lost its power, for the last of these herbals did not appear till 1711, when William Salmon published *The English Herbal, or History of Plants,* in two folio volumes of nearly 1300 pages.

These herbals, however, need no further examination. Salmon seems to have written his book in opposition to those of the systematists, with an idea of carrying on the line of Gerard and Parkinson, and of superseding their classical writings. In this attempt, however, he failed, for his book, though it had taken him twenty years to compile, met with very indifferent success.

BOOK II

THE RISE OF SYSTEM, THE AGE OF RAY, MORISON, AND GREW

BOOK II

CHAPTER VIII

THE LIFE OF JOHN RAY

Cambridge to Black Notley

THE age of the herbalists was clearly and inevitably transitory. Their work led to the accumulation of lists of plants, comprising large numbers of species. No satisfactory delimitation of species had been attained at the end of the period, and no satisfactory method of arrangement had been reached. Generally the order was alphabetical; if this were departed from no proper indications of relationship replaced it. There was, indeed, a mass of information, but from lack of systematising it was unwieldy in the extreme. Much care was exercised in identifying synonyms, but owing to defects in the accepted mode of nomenclature, plants were named with such inordinate attention to descriptive detail that each name was pretty well a description of the plant as it appeared to its discoverer. There was a sad lack of precision, and hence the names became too ponderous to be useful. Not infrequently they indicated particulars as to place of flowering, time of growth, or supposed internal qualities as well as the main descriptive features of the plants. Naturally the longer the name became in consequence of its including so much, the more confused was the identity. In the writings of nearly all the herbalists " there were nearly as many genera as species, and if they gave the same common appellation to two or more plants, they were led to it by some rude external resemblance, such as size, form of root, agreement in the colour of the flowers; and in the description of the species were frequently satisfied with comparing it to another plant, well known to themselves, and therefore left undescribed in their writings." At the end of the period it was expected that every botanist should know all the plants that had been described, a burden of no small dimensions thereby being thrown upon them. The weight of this burden led to a search for some alteration in systematic arrangement, for the minute descriptions in

vogue stood in the way of proper classification. The prolixity was, it is true, very careful, as well as elaborate, but as morphology was very imperfectly understood, much confusion was inevitable.

This appreciation of the need of change was not sudden, but made its way over opinion very gradually, and to different degrees in different countries. Though felt with much acuteness in England little advance was made for some time after the herbals had reached the highest point of their reputation. As we have seen, L'Obel made an attempt in the *Adversaria* (1570) and in the *Observationes* (1576) to distribute the plants he described into classes based on the form of the leaves, but this crude plan was not materially improved upon by Gerard and Johnson, and that was substantially all the progress that can be claimed. The groupings of the other herbalists were based upon nothing of value, and some of them were actually retrograde.

On the Continent matters were a little more advanced, though progress was not equal in all countries. In Italy, Cæsalpino had made a notable effort to introduce a natural classification, which, though not truly scientific according to modern ideas, showed a great advance upon the work of the herbalists. His scheme, published in 1583, introduced scientific method where before only general impressions had been indicated. It was especially noteworthy in that it insisted on the importance of the reproductive structures in estimating the relationships of plants. Still he had imbibed the Aristotelian philosophy, and his proposals were mixed, to no inconsiderable extent, with the errors and speculations inseparable therefrom. Strangely, his work did not exert its due influence on general thought; neither his contemporaries nor his immediate successors were much affected by it, nor is there any evidence that it had exerted any perceptible influence on opinion in England.

In Germany the work of the Bauhins, forty years later, itself a further development of the suggestions of L'Obel, had been to some extent affected by that of Cæsalpino, but it was still little more than collecting and cataloguing, with hardly any systematic arrangement.

In the *Pinax Theatri Botanici* we find Kaspar Bauhin recognising that natural affinity must be the foundation of a truly natural system, but though he abandoned the alphabetical plan of arrangement he did not claim that he had replaced it by such a system, nor that his proposed scheme of classification met its requirements. Indeed, neither of the Bauhins was able to distinguish the larger

natural groups of plants, either by name or description. In another direction the elder Bauhin was more successful, for in his *Pinax* especially he did much to clear up the confusion existing in nomenclature, which had resulted from the fact that different names had been given to particular plants by different authors. The *Pinax* not only got rid of much of this confusion by setting forth the different synonyms in use, but it introduced greater terseness of description, and helped to restrict the inordinate length of names.

The *Pinax* of Kaspar Bauhin, published in 1623, had been followed by the *Historia Plantarum Universalis* of John Bauhin in 1650. This huge book in three folio volumes was the greatest work that had appeared on the Continent, and was justly called a monument of learning and industry, of which few examples can be expected in any age. It included its author's own researches and conclusions, and comprehended the results of both ancient and modern writers, all put together with accurate and critical judgment.

We do not find, however, that for some years any great influence was exerted in England by either the *Pinax* or the *Historia*, nor was a greater effect produced by the work of another German writer, Jung, who was engaged with these problems during the middle of the seventeenth century, trying to work out the lines of a true natural system. His work was published posthumously by his pupils, Fogel and Vogelius, in 1662 and 1668. Jung was a man of similar spirit to Cæsalpino, and showed himself the possessor of keen insight. He combined the philosophic mind with the power of close observation to a degree unusual at the time, while he was free from the leaning to the Aristotelian philosophy that Cæsalpino showed, and therein he was more fitted to grasp the problems of morphology and to base a system of classification upon the foundation of the latter science. He was, indeed, the first writer to supply the basis of comparative morphology, though at his death little more than this had been attained.

It is beyond the province of this book to discuss at any length the position taken by these two masters in the development of botany. They were far before their contemporaries, showing not only the possession of more accurate ideas of the principles upon which natural classification should be based, but, further, a wonderful co-ordination of the various features of plant life, and the relations of physiology and structure to system. We can

only bring forward here their work in its influence upon the minds of the great men to whom the advance and development of thought in England was due during the latter half of the seventeenth century, though even this influence seems to have been scarcely recognised by them, and to have worked in them almost unconsciously.

While all this work was being accomplished on the Continent, England was the scene of unrest; the time of the herbalists was drawing to a close, that of the systematists had not arrived. The brilliant work of Cæsalpino, the Bauhins, and Jung produced at first little permanent result, and was followed by a period of more or less sterility, but towards the end of the seventeenth century a great revival set in, during which wonderful advances were made, to a certain extent, in the direction of systematic classification, but perhaps still more in the way of opening up new pathways to a proper appreciation, for the first time, of vegetable physiology. In this revival English botanists not only played a conspicuous part, but may be said to have actually taken the lead in the development of the science.

The new awakening in England must be associated primarily with the names of Ray and Morison, each of whom exercised a great influence upon the course of scientific development. They were contemporaries, but their work was entirely independent; their spheres of life did not bring them into close association; the one, an explorer, philosopher, naturalist, yet for most of his life a country clergyman; the other, a courtier and university professor, but both animated by a common aim—the elucidation of systematic classification, and the supersession of the empiricism of the herbalists. The labours of Ray were the more far-reaching, so much so, that in the opinion of Lindley—himself an expert in taxonomy—the classification he propounded, after the short period of domination of the artificial system of Linnæus, furnished the basis of that of De Jussieu, on which the system of De Candolle was subsequently founded; the system which underlies, to a great extent, the classification adopted by Bentham and Hooker in the *Genera Plantarum*. To Ray is thus due the germ of the classification still in vogue in England, though his proposals were very far from even indicating their final form.

Ray

John Ray, or Wray, who may justly be regarded as the father of English systematic botany was, after the death of Jung, the greatest botanist of the seventeenth century in Europe. He was spoken of by Pulteney as the Aristotle of England and the Linnæus of the time, an appreciation as great as that of Lindley, fifty years later. Unlike his great rival, Morison, he was English by birth, and Puritan by training; lacking the powerful friends to whom Morison owed so much, he never trod the pathways of courts, nor graced the lecture-rooms of the university; but gifted with a finer insight and with indomitable enthusiasm and perseverance in the study of nature, he became the foremost naturalist of his time. He explored the greater part of England and of considerable regions of the Continent of Europe, investigating chiefly the flora, and only to a slightly smaller extent the fauna, qualifying himself thus to treat of both in his subsequent writings, based mainly on the large personal experience of travel and discovery. Nor was this all, for he carried his own researches into the newly originated study of the physiology of plants, while he followed with attentive care the labours of those who were at the time attacking the problems of histological structure.

Ray was born of humble parentage at Black Notley in Essex in 1628, and, after receiving his elementary education at the Grammar School, at Braintree, was sent by his father to Catherine Hall, Cambridge, before he had completed his sixteenth year. Dissatisfied with the course of study there, he migrated in less than two years to Trinity College "where the politer sciences were more cultivated." Here he made rapid advancement in his studies, and gained great proficiency in the subjects of the Cambridge curriculum. It was an age of general education rather than specialisation, but even then it is remarkable to find him successively fellow, Greek lecturer, mathematical lecturer, and humanity (or classical) reader in the college, all these appointments being secured in the course of six years. His further college career was equally brilliant, and included the tenure of many college appointments, and of tutorship to many "gentlemen of honourable birth and attainments, who gave him due praise and acknowledgments for his watchful care of them."

Ray appears to have contemplated a career as a divine, and while at Trinity in those early days, even before ordination, was

distinguished as a sensible and rational preacher and lecturer on religious subjects. His views were those of the Puritan party, who at that time were dominant in the English theological world. At the same time, however, he showed distinct leanings to the study of nature, and gave evidence of that ardent love of botanical science which became so marked in his later life. In the pursuit of his theological studies he was ordained in December 1660, and for two years longer continued to hold his fellowship at Trinity; but the claims of conscience brought about an abrupt severance from collegiate life in 1662, ending what we may look upon as the first section of his long and busy career.

He was one of the noble band dispossessed by the Act of Uniformity, in virtue of which, among other demands, a subscription was required from the clergy against the "solemn league and covenant." The persons making it were required to swear to the proposition that the oath in question was not binding on those who had taken it. Ray found himself unable to make this declaration, and rather than do violence to his conscience, he resigned his fellowship at Trinity, and left the University.

During this earlier period of his life the study of Nature, though not his first care, had exercised a great charm for him, and he had begun to build up a reputation as a botanist. He was fortunate in having at Trinity several friends whose tastes harmonised with his own, an association which was of material assistance to him. One of these, who was associated closely with him in the preparation of his first botanical work was Nid, another fellow of Trinity and an ardent naturalist, whose early death cut short a promising career. Another who exercised the greatest influence on the course of Ray's own life, was Francis Willughby, one of his first pupils, and his whole-hearted colleague in his researches into natural history. Indeed, he may be said to have done almost as much for zoology as Ray did for botany. For twelve years the two were almost inseparable in their investigations.

We have seen how under the later herbalists the study of plants had been taken from the garden to the open country, and the exploration of vegetation in general had been set on foot. The importance of this mode of investigation appealed strongly to Ray, and botanical walks and excursions round Cambridge occupied both him and his friends during the time of his residence in the University. The results were laid before the botanical world in 1660, taking the form of a little volume entitled *Catalogus Plantarum circa Cantabrigiam nascentium*, which was the first flora of

Cambridgeshire published, and so the pioneer of the local floras. His preliminary explorations had occupied his leisure for ten years, and resulted in his being able to include in the *Catalogus* 626 plants, all varieties and doubtful plants being excluded. At the time very few of the cryptogams and not many of the grasses were known, so that the number was really more important than the mere figures would indicate. In his treatment of the subject-matter we find no trace of systematic arrangement, and the *Catalogue* was alphabetical, going on the lines of the herbalists. At the same time Ray gave very complete descriptions of his plants, quoting their synonyms as given by the older writers, their Latin and English names, their habitats, and what was known about their economic and medicinal uses. He included also an explanation of the terms used in the science, which even then were uncouth and obscure, a feature that has unfortunately not yet disappeared from botanical nomenclature and has been a hindrance to progress from almost the earliest times.

Though no trace of other than alphabetical method is shown in the body of the *Catalogus*, Ray subjoined a sketch of a system which he had himself devised. This early systematic work gave promise of what appeared later. The sketch differed in no very material way from the method of K. Bauhin, except that it showed certain evidence that Ray was, to some extent, under the influence of Jung, though as the work of the latter was only in manuscript at the time, it is probable he had only seen a copy of his notes. The *Catalogus* was further noteworthy in that the dry details of botanical description were enlivened by notes referring to anatomical points and to collateral branches of natural history, particularly entomology.

Ray acknowledges that in preparing this first work he received much assistance from Nid, his chief companion in the excursions to which it owed its origin. The success of the book was complete and instantaneous; Ray says himself that "many were prompted to these studies, and to mind the plants they met with in their walks in the fields."

We may note here parenthetically the curious coincidence, that both Ray and Morison first put forward their ideas of system in the form of an appendix to a catalogue of plants. Both schemes, however, were only tentative, and the more studied systems of the two writers appeared several years subsequently.

During the latter part of Ray's Cambridge career he devoted himself to more extended exploration. In the autumn of 1658 he

spent some six weeks in a tour through the Midland counties of England, and through North Wales, undertaken for the purpose of studying the flora. In a second journey in 1661 he was accompanied by several friends, one of whom was Willughby. They went into Scotland by way of Durham and Northumberland, returning through Cumberland and Westmorland. In the next year another journey, extending over nearly three months, was undertaken in company with Willughby. The route was through the Midland counties to Cheshire and thence into Wales, most parts of which were visited: from Wales they travelled through Somersetshire, Devonshire, and Cornwall, returning by way of Dorsetshire, Wiltshire, and Hampshire. These expeditions were marked by great keenness of search, and yielded records not only of the plants, but of the birds and fishes of the counties visited. They showed Ray to be a man of wide sympathy with the objects of Nature, a naturalist, indeed, in the widest sense.

The abrupt termination of Ray's Cambridge life followed closely upon the conclusion of this third excursion. It was a step which was fraught with difficulties of no common order, for he surrendered a position of affluence which afforded him means of carrying out his investigations with complete independence, and he was hampered by pecuniary difficulties all the remainder of his life. On the other hand, freed from the pressure of college and university responsibilities he was able to take up scientific work with greater freedom, and after a while to show himself still more clearly as essentially a man of science. It caused, however, a prolonged interruption to the investigation of the British flora, which was not resumed till 1667.

The first result of the change in his circumstances was to throw him still more closely than before into association with Willughby. The latter was a man of means, and finding Ray suddenly with no claims upon his time he broached to him a plan for a more extended scheme of exploration and investigation of the natural history of a much wider area. It involved the examination of a large part of Europe, besides the rest of England, and was to include the study of both fauna and flora, Willughby undertaking the animals and Ray devoting himself to the plants. The proposal had a great fascination for Ray, and the scheme was in due course embarked upon. It ushered in what we may regard as the second period of his scientific career, which lasted from 1662 to 1679, a period of close association with Willughby, till the death of the latter in 1672.

Before the first journey of the scheme was undertaken Ray published an appendix to the Cambridge catalogue, his last published contribution to the local flora till 1685.

The new series of excursions started in 1663, the two naturalists being accompanied by two of their friends, Skippon and Bacon, both pupils of Ray. They left Dover for Calais and travelled for three years over a large part of the Continent, embracing France, Holland, Germany, Switzerland, Italy, and part of the Mediterranean. Willughby left the others at Montpelier, and went by himself into Spain. His results were edited and published by Ray after his premature death. On this journey Ray laid the foundation for a work which appeared many years later under the title of "Catalogus Stirpium in exteris Regionibus a nobis observatarum." He returned to England in 1666.

At the time of his return one of his great friends, Dr. Wilkins, who had been master of Trinity College, and was then Dean of Ripon, and one of the council of the newly formed Royal Society, was engaged on the preparation of a work entitled an *Essay towards a Real Character and a Philosophical Language*, which was an attempt to express ideas of all kinds by symbols independent of spoken language. To this Ray contributed a series of tables of plants, quadrupeds, birds, fishes, etc., "for the use of the Universal Character." In the botanical part of this work he elaborated somewhat his ideas of system which were first sketched out in the appendix to his catalogue of Cambridge plants, and so shaped them that they became the foundation of his scheme of classification published many years later.

This work, with the arrangement of the affairs connected with his prolonged tour, occupied him till the summer of 1667, when, in conjunction with Willughby, he resumed his exploration of the flora of England. This fourth tour, which occupied them during the months of the summer of that year, took them through the counties of Worcester, Gloucester, Somerset, Devon, and Cornwall, whence they returned through Hampshire to London.

On their return Ray had the distinction of being chosen a Fellow of the Royal Society.

In 1668 he made a fifth tour, through Yorkshire and Westmorland, travelling alone, as his friend Willughby married in that year.

In the course of the next spring Ray first engaged in investigating physiological problems. To say that the science of vegetable physiology was then in its infancy is very much to understate the case. Nothing at all was adequately known, and the old specula-

tions of the Aristotelian philosophy were accepted as truth by most botanists. It is true that some years before 1669 this philosophy had been opposed in one important point by Jung, and more thoroughly by his contemporary, Van Helmont, but their objections, which substituted nothing better for the old views, remained isolated and unproductive. It is possible that Ray may have been stimulated by Jung's views, for we have seen that he was familiar with his writings. Another factor, however, must be taken into account; it was in 1664 that Merret in England, followed the next year by Major of Breslau, propounded the idea that there exists a circulation of the sap comparable to the circulation of the blood in the higher animals, a view which excited considerable interest in many quarters. Ray, no doubt, had the theory brought to his notice, and realising the importance of experimental inquiry, we find he devoted the spring of 1669 to an investigation of the motion of the sap, working in collaboration with Willughby and several other of his scientific friends. They made experiments on the birch, sycamore, alder, ash, hazel, chestnut, walnut, and willow, and their results were published in the fourth volume of the *Philosophical Transactions of the Royal Society*. They held themselves to have proved the ascent and descent of the sap, together with a certain lateral movement, but they declined to express an opinion on the existence of a regular circulation.

In the opinion of those of the time, and of many years after, these experiments were considered classic, and were very highly esteemed. They proved the ascent of the sap to take place through the woody part of the tree, but the deductions they made from their observations seem to us now crude and ill-balanced. They showed that in spring the vessels of the wood are filled with water, while in the summer they contain air. Ray says as the result of examining some of his sections, that "they precipitated a kind of white coagulum or jelly which may well be conceived to be the part which every year between bark and tree turns to wood, and by which the leaves and fruit are made." He showed, however, that water can filter in opposite directions through pieces of a branch cut off at both ends, and so disproved the view at that time current, that the cavities of the wood, and especially the vessels, are furnished with valves to hinder the return of the "lymph." This was in the days of the infancy of the microscope.

Ray's genius did not, however, lie very strongly in the direction of physiological research; his methods were crude, and his ap-

paratus inadequate. Though he continued his experiments intermittently during several years, he did not contribute anything of much importance to the solution of the problems he undertook, no information of much consequence being obtained till much later when this description of research received its impetus at the hands of Hales.

During 1669 Ray began to turn his attention to the communication to the scientific world of the results of his travels throughout England. He had made five long tours, in the course of which he had studied the plants of a very large part of the island, and he was familiar especially with the neighbourhood of Cambridge. His observations had consequently accumulated for him a mass of material which he began to put in order in 1667. He wrote in a letter to Lister in June of that year that he had been at work "in gathering up into a catalogue all such plants as I had found at any time growing wild in England, not in order to the present publishing of them, but for my own use; possibly one day they may see the light; at present the world is glutted with Dr. Merret's bungling Pinax." This promise of publication was kept three years later, when in 1670 the result of his labours appeared in the form of the *Catalogus Plantarum Angliæ et insularum adjacentium tum indigenas tum in agris passim cultas complectens.* This work was on the same lines as the Cambridge catalogue, but did not go so fully into the question of synonyms. It comprised 1050 plants, great care having been taken to exclude any that were not true species. The book ran through two editions, the second appearing in 1677; it was supplemented in 1688 by a little volume which he called *Fasciculus Stirpium Britannicarum, post editum Plantarum Angliæ Catalogum observatarum,* which itself was a considerable accession to English botany.

The year 1671 saw Ray's sixth and last botanical tour, which was taken through the greater part of the North of England. During the early part of the year he was suffering from an attack of jaundice, from which, he said in a letter to Dr. Lister, he recovered "by sticking to one medicine for four or five days, that was an infusion of stone-horse dung with saffron in ale," a remedy worth quoting as giving some evidence of the state of the medical art at that period. In this last journey he had the company of Thomas Willisel, possibly the same man who had conducted, some years before, the researches on which Merret had based his *Pinax.*

In the years 1672 and 1673, great changes took place in Ray's life. In the first of them he lost two of his oldest and most valued

friends, Dr. Wilkins, who had been made Bishop of Chester, and his pupil and colleague, Willughby. Of the latter Pulteney says, "The strictest intimacy had subsisted between them from the time of their being fellow collegians, and it was cemented by a congeniality of taste which not infrequently forms a stronger bond of union than the ties of blood." Willughby made Ray guardian to his two sons, and at the same time constituted him his literary executor, in which capacity he published his friend's researches into the fauna of certain parts of the Continent, to which reference will be made later. He left him an annuity of £60 a year, which, according to Lankester, formed the bulk of Ray's pecuniary resources during the remainder of his life. The immediate result of his new responsibilities was Ray's settling down for several years at, and in the neighbourhood of, Middleton Hall, Willughby's country seat, and abandoning his periodical tours of exploration.

In 1673 Ray married; an event which, however, did not cut short his literary activity, for at the end of the year he published the results of his continental tour of 1663-66, under the title of "Observations, topographical, moral, and physiological, made in a journey through part of the Low Countries, Germany, Italy, and France." The botanical part of the book included an appendix, in which he gave an alphabetical list of the plants under the title of *Catalogus stirpium in exteris regionibus, a nobis observatarum, quae vel omnino vel parce admodum in Anglia sponte proveniunt.*

Ray continued at Middleton Hall till 1676, when the death of the dowager Lady Willughby led to the cessation of his guardianship, and he retired to Sutton Coldfield, where he remained a year. At this period of his life he was engaged mainly in miscellaneous literary work, especially with the observations and notes of Willughby, which were of great interest, but in a very imperfect condition, and in great confusion.

At the end of 1677 he removed to Falkborne Hall in Essex, and built a house at Black Notley, his birthplace, in which he took up his residence in 1679, and in which he spent the remainder of his life.

This second period of his career, though the time of his greatest activity, was but preparatory for the final one. Had he died at its completion his prominence in botany would scarcely have attracted attention. But his indefatigable explorations during these years bore such fruit afterwards as to prove him the greatest botanist who up to his time had appeared in England.

CHAPTER IX

THE LIFE OF JOHN RAY—*continued*

Life at Black Notley.—Botanical Writings

THE third period of his life, spent in the leisure of retirement in a little Essex village, was noteworthy for the appearance of his principal writings, which showed him eminent in all branches of natural history. Though his work as botanist has brought him his greatest fame and recognition, it is owing only to its overshadowing his attainments in zoology that he is not quoted oftener as one of the leading exponents in his time of the latter science.

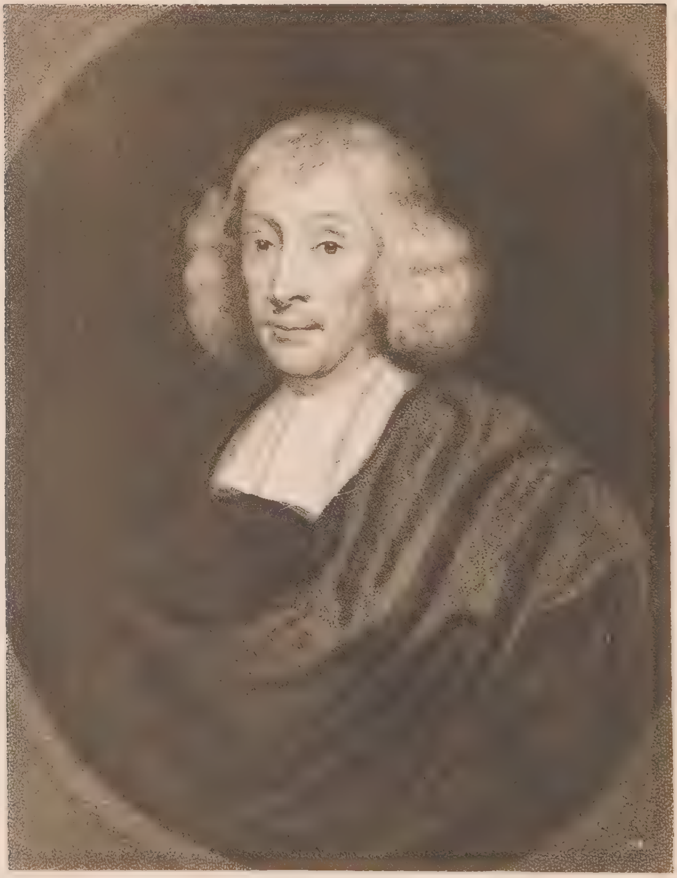
The quiet retirement of Black Notley, and the release from the cares of his guardianship, soon bore fruit. He addressed himself with ardour to the presentation of the results of his work in permanent rather than tentative form. The first publication was that of his scheme of classification which appeared in 1682 under the title of *Methodus Plantarum Nova, brevitatis et perspicuitatis causa synoptice in tabulis exhibita: cum notis Generum tum summorum tum subalternorum characteristicis. Observationibus nonnullis de seminibus Plantarum, et indice copioso.* It was a little 8vo volume of 166 pages. We have seen that he had first put forward his views in the appendix to the *Catalogus* in 1660, and that he had developed a sketch of them in his contribution to Dr. Wilkins's *Real Character* in 1667. They now took definite shape, though they were not presented in their final form, which he prepared for publication sixteen years later. But underlying them were Ray's ideas of a natural system, which should neither bring together dissimilar species nor separate those which are nearly allied. The scheme was based partly on the plan of Cæsalpino, which we have seen was at the time dominating botanical thought, but in much of it can be traced the influence of the writings of Jung, with which Ray seems to have been familiar, as he may easily have been, since their actual publication in the *Isagoge* took place in 1678. Ray strangely adopted Cæsalpino's first division of plants into trees, shrubs, and herbs, though Jung had shown that such a plan was unnatural. Another

curious mistake he made was to deny the presence of buds on herbaceous plants, making this point a distinctive one between them on the one hand, and trees and shrubs on the other. At the same time he was the first botanist to call attention to the true nature of buds, which he said were the points at which new annual plants spring up from the old stock.

Ray's first principle, apart from this initial error, was to group plants together according to the totality of their natural characters, arising from similarity in general habit. Cæsalpino before him had pointed out that, to the organs of fructification must be attached great importance in determining natural relationships, and we find Ray possessed of the same views, insisting on the value of the fruit for this purpose. He insisted also on the vegetative habit, but used the flower comparatively seldom. This appears somewhat strange in the light of the knowledge of to-day; singular, too, from the fact that Ray had some ideas on the existence of differences of sex in the vegetable kingdom, though those ideas were naturally somewhat hazy. Still the flower had a different significance for Ray than it had for many of his contemporaries, and certainly for most of his predecessors. Though he did not put those ideas prominently forward in his system, he made a great point of the structure of the seed, recognising that it contains not only an embryo, but in many cases what we now know as endosperm, a substance he called a "medulla" or "pulpa." Moreover, he was the first to use the structure of the embryo, so far as the number of its leaves or cotyledons, as a dividing mark between two great divisions which run through both his principal classes of trees and herbs. This is especially the great advance in classification which is due to him, the primary basis on which is founded the natural system so far as the angiospermous flowering plants are concerned, and we may thus attribute to him the recognition of the two great groups still known as the Monocotyledons and Dicotyledons.

The broad grasp of the subject which led him to lay down these definite principles of classification, and to insist on the large groups showing undoubted affinities was a distinctive feature of Ray's mind, and the source of the service which he rendered to taxonomy. When, however, he left the main divisions he had established and turned his attention to the subdivision of his groups he was much less successful.

In the *Methodus* in its first form, in 1682, Ray had not fully developed these ideas.



John Ray.

The scheme of classification therein propounded was the following:—

DE HERBIS

Genus.	
i.	Imperfectæ, flore et semine carentes (Algæ, Fungi)
ii.	Semine minutissimo (Bryophyta, most Pteridophyta)
iii.	Acaules Epiphyllospermæ, vulgo Capillares (Filices)
iv.	Flore imperfecto, sexu distinctæ (*e.g.*, *Humulus*, *Cannabis*, *Spinachia*, *Urtica*)
v.	Flore imperfecto, sexu carentes (*e.g.*, *Chenopodium*, *Alchemilla*, *Artemisia*)
vi.	Flore imperfecto, monospermæ, semine triquetro (Polygonaceæ)
vii.	Flore composito, Lactescentes (Compositæ, Cichorieæ)
viii.	Flore discoide Papposæ (Compositæ, most Asteroideæ and Senecionideæ)
ix.	Flore discoide nudo Papposæ (Compositæ, *Eupatorium*, *Senecio*, *Gnaphalium*)
x.	Flore composito discoide, Corymbiferæ (Compositæ, some Anthemideæ)
xi.	Flore discoide nudo, Corymbiferæ (Compositæ, the rest of the Anthemideæ)
xii.	Flore ex flosculis fistularibus, Capitatæ (Compositæ Cynareæ)
xiii.	Flore composito, Anomaleæ (*Dipsacus*, *Scabiosa*, *Echinops*, *Armeria*)
xiv.	Flore perfecto seminibus nudis singulis (*Valeriana*, *Thalictrum*, *Statice*, *Agrimonia*, etc.)
xv., xvi.	Umbelliferæ
xvii.	Stellatæ dictæ (Rubiaceæ)
xviii.	Asperifoliæ (Boraginaceæ)
xix., xx.	Verticellatæ (Labiatæ)
xxi., xxii.	Semine nudo, Polyspermeæ (acheniferous Ranunculaceæ and Rosaceæ, Malvaceæ)
xxiii.	Pomiferæ (Cucurbitaceæ)
xxiv.	Bacciferæ (*e.g.*, *Smilax*, *Bryonia*, *Tamus*, some Solanaceæ, etc.)
xxv.	Multisiliquæ seu Corniculatæ (folliculate Ranunculaceæ, *Sedum*, *Dictamnus*, etc.)
xxvi–xxviii.	Flore monopetalo uniforme (*e.g.*, *Hyoscyamus*, *Gentiana*, *Convolvulus*, *Campanula*) Flore monopetalo difformi (*e.g.*, *Impatiens*, *Aristolochia*, most Scrophulariaceæ)
xxix.–xxxi.	Flore tetrapetalo uniforme siliquosæ (Cruciferæ)
xxxii.	Flore tetrapetalo uniforme Anomalæ (*e.g.*, *Papaver*, *Ruta*, *Plantago*, *Veronica*)
xxxiii.–xxxvi.	Flore papilionaceo (Leguminosæ)
xxxvii.	Flore pentapetalo aut polypetalo, foliis conjugatim dispositis (Caryophyllaceæ, Cistaceæ, Hypericaceæ)
xxxviii.	Flore pentapetalo aut polypetalo, foliis nullo aut alterno ordine dispositis (*e.g.*, *Portulaca*, *Viola*, *Reseda*, *Geranium*)
xxxix.	Flore pentapetaloide, anomale (*e.g.*, *Primula*, *Asclepias*, *Erythræa*, *Verbascum*)
xl., xli.	Culmiferæ (Gramineæ)
xlii.	Graminifoliæ non culmiferæ (Cyperaceæ, Juncaceæ)

Genus.	
xliii.–xlv.	Radice bulbosa (bulbous Monocotyledons)
xlvi.	Bulbosis Affines (*e.g.*, *Iris*, *Alöe*, Orchidaceæ, Araceæ, *Cyclamen*)
xlvii.	Anomalæ et sui generis (*e.g.*, *Potamogeton*, *Nymphæa*, *Callitriche*, *Trapa*, *Stratiotes*, *Sagittaria*, *Cuscuta*, *Adoxa*, *Polygala*)

DE ARBORIBUS

Genus.	
i.	Pomiferæ (*Pyrus*, *Mespilus*, *Citrus*)
ii.	Pruniferæ (Prunus, *Cornus*, *Olea*, *Palma*)
iii.	Bacciferæ (*e.g.*, *Myrtus*, *Laurus*, *Buxus*, *Arbutus*, *Ilex*, *Juniperus*, *Taxus*)
iv.	Nuciferæ (*e.g.*, *Juglans*, *Corylus*, *Quercus*, *Castanea*, *Fagus*)
v.	Coniferæ (*Pinus*, *Cedrus*, *Abies*, *Cupressus*, *Larix*, *Betula*, *Alnus*)
vi.	Lanigeræ (*Platanus*, *Tamarix*, *Salix*, *Populus*)
vii.	Siliquosæ (leguminous trees, *Syringa*)
viii.	Vasculis seminum membranaceis et Anomalæ (*Ulmus*, *Fraxinus*, *Carpinus*, *Tilia*, *Acer*)

DE FRUTICIBUS

Genus.	
i.	Bacciferæ sempervirentes (*e.g.*, *Vaccinium*, *Ruscus*, *Hedera*, *Juniperus*)
ii.	Bacciferæ foliis deciduis, non spinosi (*e.g.*, *Vitis*, *Lonicera*, *Cornus*, *Sambucus*)
iii.	Bacciferæ foliis deciduis, spinosi (*Catægus*, *Ribes*, *Rosa*, *Berberis*, etc.)
iv.	Seminibus nudis, aut vasculis siccis inclusis (*e.g.*, *Vitex*, *Rhus*, *Spiræa*, *Erica*)
v.	Floribus papilionaceis (*e.g.*, *Acacia*, *Genista*, *Cytisus*)
vi.	Suffrutiscentes (a miscellaneous collection of species)

The publication of the *Methodus* attracted criticism abroad. Rivinus, who was then the leading botanist in Germany attacked it rather severely some few years later, and a prolonged controversy took place between him and Ray. Rivinus published his own views on classification in 1690, putting forward a scheme based largely on the form of the corolla. He did not use the distinction into trees and herbs, which Ray made his first feature, and which was a main point of Rivinus' criticism. In his reply, which appeared in 1694, in the preface to the *Sylloge*, which we shall presently notice, Ray defended this distinction, resting it on the supposed absence of buds from herbaceous plants, and attacked in his turn Rivinus' plan of depending for his divisions principally on the flower, and especially on the corolla, pointing out that many of Rivinus' diagnostic marks were variable and uncertain, and that he separated plants which have evident affinities because of differences in mere number in the petaline whorl. He also

objected to Rivinus' dependence on certain features of the fruit, which he treated in a different way from his own proposals.

The tone of the controversy was extremely high and courteous. Ray says of his opponent, "Rivini equidem opus vehementer laudo," while Rivinus in his turn writes, "Et botanicorum quotquot fuerunt facile principem noveram."

In 1696 Ray's work was attacked by Tournefort, who had just put forward proposals for classification in his *Elements of Botany*. Tournefort frequently quoted Ray in this work, and almost always charged him with inaccuracy or error, objecting to many of the details of Ray's descriptions, though agreeing with him in the main in basing his divisions on the fruit. Ray defended himself by claiming that the characters to which Tournefort objected would render recognition of the plant to which they applied more easy. The illustrious rivals always, however, professed for each other the highest esteem.

These prolonged controversies were beneficial in causing Ray to re-examine and in some important particulars to modify his system, which he did in 1698, when he gave it its final form. In consequence of some difficulties with his publishers, perhaps on account of the small demand for scientific books, this edition was not printed till 1703, when it was published at Amsterdam, under the care of Dr. Hotten, Professor of Botany at Leyden, under the title, *Methodus Plantarum emendata et aucta*. It was reprinted at Amsterdam in 1710, and at Tübingen in 1733.

In its final form as revised by Ray in 1698, he prefaced it by a sketch showing how his ideas on system had gradually progressed; he dated his views in the main from the tables drawn up in 1666 for the use of Dr. Wilkins's *Real Character*, and gave his own account of the controversies with Rivinus and Tournefort, showing why he maintained the views he set forth. In this edition he dropped his original division into three groups, claiming trees and herbs only, and introduced the structure of the embryo as a distinguishing characteristic.

The final system of Ray was the following:—

A. PLANTÆ GEMMIS CARENTES (HERBÆ) [1]

(*a*) *Imperfectæ*

i. Plantæ submarinæ (chiefly Polypes, Fucus)
ii. Fungi
iii. Musci (Confervæ, Mosses, Lycopods)
iv. Capillares (Ferns, Lemna, Equisetum)

[1] This table is taken from Sachs' *History of Botany*. The explanations of the classes put in brackets are his.

(*b*) *Perfectæ*

DICOTYLEDONES (BINIS COTYLEDONIBUS)

v. Apetalæ
vi. Planipetalæ lactescentes
vii. Discoideæ semine papposo
viii. Corymbiferæ
ix. Capitalæ (vi.–ix. are Compositæ)
x. Semine nudo solitario (Valerianeæ, Mirabilis, Thesium, etc.)
xi. Umbelliferæ
xii. Stellatæ
xiii. Asperifoliæ
xiv. Verticellatæ (Labiatæ)
xv. Semine nudo polyspermo (Ranunculus, Rosa, Alisma)
xvi. Pomiferæ (Cucurbitaceæ)
xvii. Bacciferæ (Rubus, Smilax, Bryonia, Solanum, Menyanthes)
xviii. Multisiliquæ (Sedum, Helleboreæ, Butomus, Asclepias)
xix. Vasculiferæ monopetalæ (various)
xx. Vasculiferæ dipetalæ (various)
xxi. Tetrapetalæ siliquosæ (Cruciferæ, Rutæ, Monotropa)
xxii. Leguminosæ
xxiii. Pentapetalæ vasculiferæ enangiospermæ (various)

MONOCOTYLEDONES (SINGULIS AUT NULLIS COTYLEDONIBUS)

xxiv. Graminifoliæ floriferæ vasculo tricapsulari (Liliaceæ, Orchideæ, Zingiberaceæ)
xxv. Staminæ (Grasses)
xxvi. Anomalæ incertæ sedis

B. PLANTÆ GEMMIFERÆ (ARBORES)

(*a*) *Monocotyledones*

xxvii. Arbores arundinaceæ (Palms, Dracæna)

(*b*) *Dicotyledones*

xxviii. Arbores fructu a flore remoto seu apetalæ (Coniferæ and various others)
xxix. Arbores fructu umbilicato (various)
xxx. Arbores fructo non umbilicato (various)
xxxi. Arbores fructu sicco (various)
xxxii. Arbores siliquosæ (woody Papilionaceæ)
xxxiii. Arbores anomalæ (Ficus)

Though the systematic part of the *Methodus* has attracted most attention, the work has another value as embodying Ray's views on certain of the morphological questions which were exciting controversy. In separate essays he discussed the problems of the nature of the seed and of the leaves and flowers, showing incidentally how much he was under the influence of Jung's writings. In his observations on the seed we find the first allusions to the great difference between the Monocotyledons and the

Dicotyledons, which we have seen he was subsequently the first to use in classification.

Ray claimed that the system of the *Methodus* was a fair attempt to fix natural relationships or classes. He said that it was a rule with him that no plant should be separated from its tribe for a single note of difference, but that all points should be considered and given their true value. It is, however, difficult to see why having adopted such a plan, he divided the well-marked natural group, the Compositæ, into four classes, the points of distinction between them being comparatively unimportant. He did not reach his ideal in many other respects in arranging his classes, for the characters of the smaller divisions are often incongruous; he based generic distinctions on vague details, such as the shape of the leaf, the colour of the flower, taste, smell, the dimensions of the plant, and other points unsuitable for purposes of diagnosis. A fundamental defect is the division of plants into trees and herbs, but though, in his prefatory remarks in the *Methodus*, he disparages that principle as unphilosophical, he retained the plan with great obstinacy on the plea of its convenience. Sachs found great fault with the subordination and co-ordination which the system presented, and criticised very severely many of the divisions, showing them to be unnatural. He pointed to the inclusion of polypes and sponges among plants, and to the hopeless confusion of the grouping of the cryptogams.

Still, with all its defects, Ray's system was the best effort of the seventeenth century. Lindley writing of it 150 years later said it "unquestionably formed the basis of that method which, under the name of the system of De Jussieu, is universally received at the present day" (1850).

The book in its second and subsequent editions was much approved abroad, and its method was taught widely by some of the most eminent professors on the Continent.

The first edition of the *Methodus* was regarded by Ray as preparatory to what he had long contemplated—a general history of plants. This was originally planned during the period of his botanical excursions, largely at the instigation of Willughby, and was to be based partly on the results of his own explorations and partly on contemporary writings, together with such as were extant at the time. He had accumulated a large store of material when his plans were thrown altogether out of joint by the death of Willughby in 1672, and the consequent changes in his own life. Almost at the same time he heard that Morison, the distinguished

Professor of Botany at Oxford, had in contemplation a similar task, a very important contribution to which was published in the following year (1673). For various reasons all highly creditable to Ray the latter was unwilling to enter upon a rivalry with Morison, and for a time abandoned his cherished idea. Morison, however, died in 1683, and left his work incomplete, the greater part indeed unwritten. At this juncture the *Methodus* being just issued, and Ray consequently at leisure, he was induced, by the persuasion of friends, to resume the great undertaking. In carrying it out he had the assistance of many of his botanical colleagues, conspicuous among whom were Sir Hans Sloane and Dr. Tancred Robinson. We find it occupied his attention for five years, when it took the form of two large folio volumes, the first appearing in 1686, the second in 1688, bearing the title, *Historia Plantarum generalis*. The work was finally completed sixteen years later by the issue of a supplementary third volume, which was published in 1704, just before the death of its author.

This monumental work forms a compendium of the botanical knowledge of the time. It is no mere catalogue of plants, as were the ancient herbals. In its opening chapters we find a comprehensive account of what had been discovered of the anatomy and physiology of the vegetable organism, embracing the discoveries of Malpighi and Grew, as well as the results of his own researches in that field. Of this Sachs says it is a general account of the science in fifty-eight pages, which printed in ordinary size would itself make a small volume, and which treats of the whole of theoretical botany in the style of a modern textbook. It also expounds morphology as it was understood by Jung and other continental writers, and gives a concise, methodical, and accurate account of the conditions of the science and the trend of thought at the time. After this general introduction Ray describes separately the plants then known ; starting with those which were met with in the writings of the Bauhins, he deals with those of Mexico, Brazil, the East Indies, Italy, Sicily, and those observed during his own journeys, embracing finally the contents of the first six volumes of the *Hortus Malabaricus*, with many from less known works. He arranges all of these on the lines of the new system which had been set out in the *Methodus*, making only a few modifications. About 6900 plants were dealt with in the first two volumes. The book is thus a complete handbook of botany as understood at the time Ray wrote, and occupied the place taken in recent times of the famous textbooks of Sachs and other writers.

The *History* has met with nothing but eulogy from the writers who have criticised it. Cuvier and Du Petit Thouars wrote in the *Biographie Universelle*, " He has displayed the rare talent requisite to bring his scattered observations into one point of view, and here may be found the principal discoveries in the nature of plants made by Cæsalpinus, Columna, Grew, Malpighi, and Jung, in addition to those made by Ray himself, and in this way resulted the most complete treatise which has as yet appeared on vegetation in general." Pulteney says of it, " We come now to that performance which Linnæus and Haller so justly style *Opus immensi laboris ;* and which considered as the work of one man has perhaps been exceeded by none, unless indeed by that of John Bauhine. . . ." " It is not easy to refer the modern student to a more perfect view of the state of this science near the close of the last century [1] than will here be found ; while the work itself exhibits the great improvement it had received since the beginning of the same period, and to which the author had himself contributed in an eminent degree."

Sir J. E. Smith, first president of the Linnean Society of London, expresses similar appreciation of the book. " This vast and critical compilation is still in use as a book of reference, being particularly valuable as an epitome of the contents of various rare and expensive works which ordinary Libraries cannot possess, such as the Hortus Malabaricus. The description of species is faithful and instructive, the remarks original, bounded only by the whole circuit of the botanical learning of that day ; nor are generic characters neglected however vaguely they are assumed. Specific differences do not enter regularly into the author's plan, nor has he followed any uniform rules of nomenclature. So ample a transcript of the practical knowledge of such a botanist cannot but be a treasure."

As already mentioned, sixteen years after the work was completed Ray brought out a supplementary volume. During this long interval the science had developed considerably ; the number of plants that were known had been greatly increased, the *Hortus Malabaricus* had been completed, Sloane and Petiver had collected herbaria of many hundred plants that still lacked adequate description, Bobart had made contributions to the science, Sherard not only supplied more than a thousand species, but volunteered to revise the book for press. Ray was at the time much enfeebled by advancing years and protracted ill-health, but

[1] Pulteney wrote in 1790.

with the assistance of many friends he was able to complete the work and see it published before his death. This supplementary volume contained the enumeration of 11,700 plants.

But before this final volume appeared Ray made many other contributions to science. His energy after he settled at Black Notley was almost unexhaustible. No sooner had the second volume of the history appeared than we find him engaged on further editions of his earlier works. In 1688 appeared the *Fasciculus Stirpium Britannicarum*, an enlarged edition of the *Catalogue of English Plants* of 1670. He was, however, dissatisfied with this presentation of the British flora, and accordingly, even while the *Fasciculus* was in course of publication, remodelled and, with the assistance of several of his friends, considerably enlarged it. On the eve of publication of this new edition a dispute with his publishers led to its appearance as a totally new work. He accordingly abandoned the alphabetical arrangement of the *Catalogue*, and grouped his plants according to his scheme of classification. After a certain postponement, owing to what his biographer calls the "delays and tricks of the bookseller and printer," it saw the light in the year 1690, appearing under the title, *Synopsis Methodica Stirpium Britannicarum*.

It was a little 8vo volume, which became the field companion of the botanists of the day in their "simpling" excursions. It has indeed been the basis on which the floras of England subsequently published have been founded. It was simplified and made more generally useful than its two predecessors by its systematic arrangement, the reconsideration of generic characters, the increased number of plants it described, the greater accuracy of their synonyms, and the relegation to an appendix of their uses and medicinal qualities. A great testimony to its excellence is borne by Sir J. E. Smith. Writing in the *Transactions of the Linnean Society* he says: "Of all the systematical and practical floras of any country the second edition of Ray's Synopsis is the most perfect that ever came under our observation. He examined every plant recorded in his work, and even gathered most of them himself. He investigated their synonyms with consummate accuracy, and if the clearness and precision of other authors had equalled his, he would scarcely have committed an error. It is difficult to find him in a mistake or misconception respecting Nature herself, though he sometimes misapprehends the bad figures or lame descriptions he was obliged to consult."

In 1694 he published the results of his foreign travels and

explorations of earlier years in the *Stirpium Europæarum extra Britannias nascentium Sylloge.* In this work he did not confine himself to his own discoveries, though these formed the main contents of the book; he incorporated with them much information derived from the work of continental writers. He added also a remarkable feature in the form of a geographical view of the distribution of the plants he had observed. The *Sylloge* is noteworthy, moreover, for the fact that in his prefatory remarks he makes the admission that the old classification of plants into trees, shrubs, and herbs, to which he adhered so resolutely in his earlier writings on system, cannot be regarded as a truly philosophical conception.

A second edition of the *Synopsis* appeared from his pen in 1696, the last during his life. The third edition, which was for so long the standard English flora, was published in 1724 after his death, under the direction of Dillenius.

Besides this general flora of England Ray brought out about this time several provincial catalogues of plants, not independently, indeed, but in Camden's *Britannia* of 1695. In these he put together the local notes which he had made years before on the botany of the districts which had been the scenes of his investigations during his excursions about England in the time of and after his residence at Cambridge.

The enormous advance that was made in botanical knowledge during Ray's life, due in no small degree to his own energy and application, can be appreciated by a comparison of the first edition of the *Catalogus Plantarum Angliæ* with the second edition of the *Synopsis.* It was marked especially by the information that had been obtained respecting the cryptogams. Practically unknown as these were at the beginning of the period, the *Synopsis* contained records of more than 500 species of them.

It was during these years at Black Notley that the controversies between Ray, Rivinus, and Tournefort took place, and no doubt during that time Ray's views on classification were matured and developed. A further contribution to the subject appeared, indeed, in the second edition of the *Synopsis*, which included, or was accompanied by, a *Dissertatio de variis plantarum methodis brevis.* In this he claimed that the fixation of the marks of class and genus could not be held to have been finally determined if based upon the fruit alone; that the habit of a plant must have its due weight, for many plants which agree in floral structure differ materially in habit, and *vice versâ.* He defended his own

method of leaning chiefly on the fruit rather than the flower, criticising rather severely Tournefort's preference for the latter.

Ray's final word on system appeared in the second edition of the *Methodus*, published, as we have seen, at Amsterdam in 1703, five years after he had completed it.

Almost alone among continental botanists Linnæus appears to have entertained a less appreciative opinion of Ray's work. He held that he was distinguished as a collector, and had a great gift for description, but he denied to him the position in classification that was awarded him by the botanical world in general. Indeed, he accused him with a certain bluntness of taking from Tournefort's labours the great differences that separate the later editions of the *Methodus* from the first, and in general of appropriating the work of Cæsalpino. This view of his position was, however, peculiar to Linnæus, whose contemporary and correspondent, Haller, dissented completely from such an opinion. We have already referred to the views of Rivinus and Tournefort.

CHAPTER X

THE LIFE OF JOHN RAY—*continued*

Ray's Contemporaries

THE influence of Ray on the progress of botanical science was not confined to his personal work. Round him gathered, as was very natural, most of the men of his time who took an intelligent interest in the study of Nature, and much of the work they accomplished may be attributed in considerable measure to his friendship and the stimulus which it brought to them. Of his great friends and helpers we have alluded particularly to Nid, Willughby, and Bishop Wilkins, all of whom influenced him very materially, and to all of whom he was of great service. But there were others with whom he corresponded less widely known than these, and whose labours are recorded in various sections of his writings. No doubt the influence was reciprocal, and almost certainly his friends gained more from him than they gave, still the fact remains that many portions of his larger works owe something of their completeness to their assistance and collaboration.

Among the features of interest in the botanical world towards the end of the seventeenth century was the enterprise shown by the Apothecaries Company in the founding of their famous physic garden at Chelsea, to which attention will be called at some length in a subsequent chapter. Though Ray had no share in this departure he numbered among his friends and collaborators, several of those who were most closely connected with the garden. The first Superintendent and Demonstrator of Plants was Mr. James Doody, who survived Ray only a year. He had much to do with the organisation of Chelsea, but his chief work was especially devoted to the elucidation and illustration of the Cryptogamia. In this he was successful, and as he cordially assisted Ray we find, not unnaturally, that in the early editions of the *Synopsis* the list of these lowly forms was much amplified by his contributions. Ray had a very high opinion of his judgment and of his skill in diagnosis. His reputation extended beyond his native country ; De Jussieu spoke of him as " inter Pharmacopæos

Londinenses sui temporis Coryphæus." To Doody's work at Chelsea we shall return later on.

James Petiver, who succeeded Doody as Demonstrator of Plants in the physic garden, was also a friend and collaborator of Ray, giving him assistance with the second volume of the *Historia*, and contributing to the third volume descriptions of a large number of Chinese, African, and Indian plants. Petiver was himself rather a prolific writer, but he did not leave any very distinct impression on the development of the science. The work which distinguished him most particularly in British botany was done after Ray's death. It was "A Catalogue of Mr. Ray's English Herbal, illustrated with figures," and was published in 1713 with a continuation two years later. Petiver made a large collection of natural history specimens, constituting a large museum, which was sold after his death for several thousand pounds. He died in 1718.

In the arrangement of the second volume of the *Historia*, Ray was assisted to a considerable extent also by Dr. Leonard Plukenet, a botanist of some pretensions, but of great modesty. Born in 1642, he published little or nothing till he was fifty years of age, when there came from his pen four works of some importance in fairly rapid succession. The first of these, the *Phytographia*, appeared in four parts, between the years 1691 and 1696; in the latter year came the *Almagestum botanicum;* in 1700, the *Almagesti Botanici Mantissa;* and in 1705, shortly before his death, the *Amaltheum Botanicum*. The *Phytographia* consisted of a series of figures, chiefly, though not exclusively, of many new and rare species of exotic plants, of which Plukenet gave many delineations. The *Almagestum* was largely concerned with the identification of the plants of the ancient writers ; it was a catalogue of some 6000 species. In it Plukenet showed great skill in determining and verifying synonyms. Besides his writings Plukenet left behind him a herbarium of 8000 specimens, which is now in the British Museum. Though thus an author of considerable industry he does not appear to have been possessed of much originality, or to have advanced the development of the science. In both his writings and his collecting he was mainly dependent on the assistance of correspondents, for he travelled very little. Towards the end of his life Queen Anne appointed him Superintendent of the Garden at Hampton Court, and Royal Professor of Botany, posts which he held till his death in 1705.

Among those Chelsea friends from whom Ray derived assistance

a very conspicuous place must be given to Dr. (afterwards Sir) Hans Sloane, who corresponded with him during the last twenty years of his life. Sloane played a very considerable part in the botanical world during the first half of the eighteenth century, and his life and work will therefore come under review in a subsequent chapter. The way, however, in which his career was intertwined with Ray's may be more appropriately noticed here. Sloane spent several years in Jamaica, and as this island and the West Indies generally were then practically unexplored so far as their flora was concerned he had exceptional opportunities and facilities at his command. These he diligently availed himself of, and made himself an authority upon the botany of the West Indies. When he returned to England, about 1694, he brought back 800 species of plants with him, an account of which he published in a *Prodromus* after his arrival. With great generosity he gave Ray permission to use his manuscripts, which were of great service to him in the compilation of the third volume of the *Historia*, all being incorporated with the descriptions in full. Not only the *Historia*, but the *Synopsis* benefited by Sloane's labours, for the second edition contains a list of English plants which he had observed growing wild in Jamaica.

Dr. W. Sherard, in his earlier years, also communicated to Ray several lists of plants which were published in the *Synopsis* and in a supplement to the *Sylloge Stirpium Europæarum*. To Sherard's labours we shall refer later. For help in completing the third volume of the *Historia* Ray was indebted also to John Banister, who supplied him with lists of the plants of Virginia, and to Wm. Vernon and David Kreig, who rendered him indirectly similar service with the plants of Maryland, a collection of which they had sent to Sloane, who put them at Ray's disposal. Vernon was a Fellow of St. Peter's College, Cambridge, and an enthusiastic botanist, who, like Doody, devoted himself largely to the Cryptogams. James Cunningham was a correspondent of Ray, Plukenet, and Petiver, and resided for a long time in the East. He occupied himself largely in collecting the plants of parts of China, and made considerable communications to Plukenet's *Amaltheum*, and so indirectly to Ray's *Historia*.

A London physician, Dr. Tancred Robinson, was one of those intimate friends whose companionship Ray enjoyed during the greater part of his life. Ray called him, "Amicorum Alpha," and in the preface to the *Historia* in 1686, bore witness to his kindness and assiduity in correcting and enriching his work.

Robinson gave assistance especially in preparing the *Synopsis* for the press, and his genial kindness evoked many encomiums from the grateful author.

His friend and neighbour, Samuel Dale of Braintree, seems to have afforded an illustration of the influence Ray exerted on the careers of other men. He assisted Ray in collecting plants and in preparing the *Historia* for press. The bent given to Dale's mind by this collaboration resulted in his devoting himself to natural history, and especially to botany. As a physician he was necessarily interested in medicines, and we find him accordingly writing a work on this side of the science, which was one of the earliest rational books on the subject. He called it *Pharmacologia, or Manuductio ad Materiam Medicam;* it appeared in 1693, and ran through several editions. The plants were arranged according to Ray's method, but the descriptions were given in greater detail than by Ray. The work was especially valuable in having collected together a large number of synonyms, a department in which Dale was extremely proficient—indeed, Ray called especial attention to his work in that capacity in the *Historia*. Dale was born in 1659, was elected a fellow of the Royal Society in 1730, and died in 1739.

Another of Ray's friends, in a much humbler station, claims mention here. Thomas Willisel was one of those naturalists who devoted themselves to the exploration of the British flora, one of those obscure workers who were indefatigable in their explorations, but caring little for fame, put their results at the disposal of more prominent men. Willisel was satisfied to do the spade work of the science, and, working for the advancement of knowledge for its own sake, devoted most of his life to collecting plants. He was employed by Morison soon after the latter went to Oxford, he worked five years in accumulating material for Merret for the *Pinax*, he made a prolonged excursion into Ireland at the instigation of Dr. Sherard, was Ray's companion on his last tour, and was subsequently employed on similar work by the Royal Society. Most of his results were incorporated in the writings of the authors mentioned. It is recorded of him by Pulteney, that during his journeys he observed eleven host plants of the mistletoe. Another correspondent of Ray's made a considerable mark as a botanist, though unfortunately he left no permanent record of his work, his death preventing its completion. Andrew Buddle by name, he was born soon after the Restoration, and educated at Cambridge. He took up especially, at the outset of his botanical studies, the

group of the mosses, and made himself a good reputation in connection with them. By the end of the century he stood easily first among cryptogamic botanists. The grasses next claimed his attention, and his collection of specimens of the two groups became the best in the kingdom. In his pursuit of these he became intimate with Doody and Petiver, as well as with Dale, the pharmacologist of Braintree.

Like so many of the men of science of that century he took orders in the Church, and exercised his profession first in Suffolk and subsequently in London.

His researches in the field of general systematic botany were carried out in the neighbourhood of London. Associating on terms of close friendship with Doody and Petiver, the influence of Chelsea seems to have drawn him away from his original field, and early in the eighteenth century he set himself to write a new English flora. It was intended to be an improvement on Ray's *Synopsis*, a task of some difficulty, though, of course, Ray's work did not set out to be complete. Writing after Ray's death, Buddle says, "I have prepared a book ready, but we can't agree about a method. I have jumbled Mr. Ray's and M. Tournefort's together. . . . Some think I favour too much M. Tournefort, which is a reflection upon Mr. Ray which I am sure I do not design."

Buddle died about 1715, before the task he had set himself was completed. His herbarium was extremely useful in determining the plants of Ray's *Synopsis*, as he took the greatest care that all his specimens were correctly named. The herbarium passed into the hands of Sloane.

Ray died at Black Notley in 1705, working up to within three months of his death. His last two years were devoted mainly to the production of the third volume of the *Historia*, to which we have already alluded. He was buried in the churchyard at Black Notley.

In this sketch of his life and labours we have taken account only of his botanical work, as most germane to our subject. We cannot, however, pass over much that he did in other subjects. A work of some importance was his edition of Staphorst's translation of Rauwolf's travels, in which much information was afforded of the botany of the East. The work having been written in the Dutch language was of little use to the English reader, and was fast losing its place in literature. Sir Hans Sloane procured a copy from the Royal Society and employed Staphorst to translate it under Ray's supervision. It formed the first volume of a work

published by Ray in 1693, under the title of *A Collection of Curious Travels and Voyages*, 2 vols. 8vo. In the field of zoology Ray was one of the most conspicuous figures, indeed, one of the most eminent authorities of the time. Cuvier, indeed, speaks of his work as "the basis of all modern zoology." Besides many minor books and contributions to the learned societies, he edited Willughby's *History of Birds*, published posthumously in Latin in 1676. To his *History of Fishes*, ten years later, Ray contributed the first and second books. In 1693 he published his *Synopsis Methodica Animalium, Quadrupedum, et Serpentini Generis*, which Pulteney says was the first truly systematic arrangement of animals since the days of Aristotle, and followed it in the course of the next year or two by similar works on birds and fishes; which were published, however, only after his death. He was also a very able writer on literary and theological subjects.

Ray stands out amongst his contemporaries as the most distinguished man of science of his time. Haller spoke of him as "the greatest botanist in the memory of man." Sir J. E. Smith held him to be "the most accurate in observation, the most philosophical in contemplation, the most faithful in description amongst all the botanists of his own or perhaps any other time. Pulteney said that he "totally reformed the studies of zoology and botany, and raised them to the dignity of sciences." He has been held by some to have been much in advance of his time in denying the dogma of the fixity of species and in upholding their transformation, and consequently in upholding the theory of the descent of present forms from others by variation. His writings, however, hardly support this claim. He does not speak of the appearance of new forms, but says that a particular form may change into another already existing one, instancing a case in which a gardener claimed to have raised cauliflower seed which on germination produced only common cabbage. He held that all affinities must present themselves in a series that would be represented by a straight line. This, again, is hardly in accord with modern thought. Sachs says of him that "another saying of his, that Nature refuses to be forced into the fetters of a precise system, shows the dawn of the knowledge which afterwards led in Linnæus to a strict separation of the natural and artificial systems."

Not only was he conspicuous as a naturalist, but he must rank as the best type of the old Puritan scholar. Brilliant in his attainments, possessed of a fascinating style of descriptive writing,

he was modest in demeanour, of great affability, and full of charity in his dealings with all men. His industry, especially in his later years, was indefatigable, and he showed a wonderful power of overcoming the difficulties consequent on feeble health and advancing age. He stands out with the other great Puritans of his time by his noble adherence to principle, and the readiness with which he gave up the most brilliant prospects at the call of conscience. His writings, too, contain no word of bitterness for those who, by their intolerance, wrecked his early career. Derham, his biographer, says of him, "In his dealings, no man more strictly just; in his conversation, no man more humble, courteous, and affable; towards God, no man more devout; and towards the poor and distressed, no man more compassionate and charitable, according to his abilities."

CHAPTER XI

THE LIFE OF ROBERT MORISON

THE other great pioneer of system was less of a natural philosopher than Ray. His botanical work was begun on the Continent, and his reputation was assured before he came to England at all. His life led him rather into courts and the higher places of university life than with the scenes of woodland nature. He was not so much of an explorer as Ray, but rather a critic and a thinker, dealing with the accumulated materials of others. Not that he was unfamiliar with Nature, for in his younger days he applied himself diligently to the exploration of certain parts of Europe, and he had, further, the charge of a notable botanic garden. It was, however, as a teacher and professor that he was most widely known.

Robert Morison was of Scottish nationality. He was born at Aberdeen in 1620, being thus nearly ten years Ray's senior. Like the latter he was at first destined for the Church, and his early education had a bearing upon such a career. He entered Aberdeen University with this view, holding one of the Liddel bursaries, but soon preferring secular to theological studies, he turned his attention first to mathematics, and subsequently to medicine and botany. His university course closed with his graduation as Doctor of Philosophy at the age of eighteen.

On leaving college, Morison became involved in the troubles of the time, and took part in the Civil War, joining the side of the Royalists. After the final ruin of his party, he took up the study of botany at Paris, under M. Robin, or Robins, botanist to the King of France. He rapidly made a name for himself, and, gaining favour with his teacher, he was by him introduced to the King's uncle, the Duke of Orleans. This gave Morison his first opening, for the Duke appointed him steward of his garden at Blois, a post he held from 1650 to 1660, when his patron died.

During these ten years the Duke enabled him to prosecute his studies of the vegetable kingdom, not only by the aid of the resources of the garden, but by personal exploration of many of the provinces of France, the discovery of new plants being followed by their cultivation at Blois.

It was during this period that Morison seems to have had in contemplation the promulgation of a new method of classification, though he did not actually frame it till later in life. Like Ray he became deeply impressed with the imperfection of the then existing schemes of arrangement the more closely he was brought into contact with the actual flora.

His association with the Duke of Orleans had a great effect upon Morison's subsequent career. It brought him into contact with Charles II., who stands out conspicuously among English monarchs as a patron of science. On his restoration in 1660, the Duke of Orleans being then dead, Charles invited Morison to England. Though great efforts were made in high quarters to induce him to remain in France, he accepted the invitation, and was made Physician to the King. He was given the title of the Royal Professor of Botany, and was appointed to the superintendence of the royal gardens with what was for the time the handsome salary of £200 per annum and a house. Almost at the same time he was elected a Fellow of the Royal College of Physicians.

During the years which immediately followed this appointment Morison was engaged on a work which considerably enhanced his reputation, and which led to his taking a very prominent place in the botanical world. There was existing a publication by Dr. Bruyner, sometime Physician to the Duke of Orleans, which was a catalogue of the plants growing in the Duke's garden at Blois. Morison brought out in 1669 a work, *Preludia Botanica*, which was originally based upon this catalogue, known as the *Hortus Blesensis*, but which was supplemented by two very important additions. He claimed to have added the descriptions of 260 plants to the catalogue, most of which he had discovered in his own botanical wanderings, and had subsequently cultivated in the garden. This section of the book was comparatively unimportant, for some of his plants were not new at all, and others were not more than varieties. He took the opportunity, however, of making a minute examination of K. Bauhin's *Pinax*, and the second section of his book formed a detailed and well-grounded criticism of the arrangement put forward in the *Pinax*, while it defended with much ability the view taken many years before by Cæsalpino that the foundation of the genera of plants properly depends on the character of the reproductive parts, especially the fruit. It is much to be regretted that this part of the book was written in no sympathetic spirit; not content with criticising and correcting such mistakes as he found in the *Pinax*, Morison

was led into an unworthy attitude of condemnation, holding the Bauhins up to ridicule by alluding to their writings as "Hallucinationes Caspari Bauhini in Pinace tum in digerendis quam denominandis Plantis, et his Animadversationes, in tres Tomis Historiæ Plantarum Johannis Bauhini." Haller commented severely on this mode of treating those illustrious botanists, calling Morison's work "invidiosum opus." Morison treated the *Pinax*, indeed, as if the work of the Bauhins had been intended to found a system, and to offer it for acceptance and criticism. This was unfair; though they held their arrangement to be a great advance upon an alphabetical one, they made no such claim as Morison implied. There is no doubt that they were in advance of their time as we have already seen, for their proposals were based on ideas of affinity, which in turn were founded upon resemblances and differences of habit. But the main idea of the *Pinax* was to clear up the confusion that had resulted from the very free adoption of synonyms.

In the first part of his work Morison did not attempt anything constructive. In the main he followed in its arrangement the method of the herbalists, giving full descriptions of the plants, with but little attempt at systematic classification. But after having criticised the *Pinax*, he gave in a second appendix a sketch of the ideas he had formed on the subject of classification. The chief feature of his proposals was that generic characters should be based on the morphological features of the fruit, and not, as had been done by the herbalists, on supposed qualities or medicinal properties. He did not, however, commit himself at that time to a definite scheme, nor go minutely into details. His proposals were apparently largely based upon those of Cæsalpino, though he made no acknowledgment of their source.

There was thus a general agreement between his views, published in this form in 1669, and the ideas of Ray which had been put forward two or three years before. The latter, which had appeared in the tables supplied to Dr. Wilkins's *Real Character*, attracted less attention than the work of Morison, which, coming from a man occupying such an important position, made a much greater impression; so much so that a general opinion has prevailed that Morison's work was the real indication of the dawn of systematic botany in England.

Morison's proposals attracted much attention on the Continent, and met with considerable approval among the leading botanists abroad. Sprengel especially gave him credit for laying the

foundation of a better arrangement than had up to that time found acceptance, and for making a more correct discrimination of genera and species.

In England important results followed. In the year that saw the publication of his book Morison was introduced to Mr. Obadiah Walker, the Master of University College, Oxford, to the Dean of Christchurch, and to other leading members of the University. Botany was not in a flourishing condition at Oxford at the moment; the botanical garden that had been established there thirty-seven years before had seen several vicissitudes, its revenues had fallen off, and though Sir John Danvers had settled it on the University in pursuance of the will of the Earl of Danby so that it should be kept in order, and a professor and a gardener be maintained upon an adequate scale, no professor had been elected. An opportunity to remedy this state of things was at this juncture afforded; Morison was a man of high standing, and of European reputation, and, holding high appointment at court, was not dependent upon a university stipend. His new friends seized the opportunity and recommended him to be appointed Professor of Botany, "whereupon by the great testimonies and recommendations of his work he was elected on December 16, 1669, and was incorporated Doctor on the following day. He made his first entrance as botanical lecturer in the physic school on September 2, 1670, and on the 5th of the same month translated himself to our Physic Garden where he read in the middle of it, with a table before him, on herbs and plants thrice a week."

The stipend of Morison's Oxford Chair was but a moderate one, being only £40 a year. He retained, however, his position at court, and received the emoluments attached to the post of King's Botanist.

One of Morison's first publications, after his Oxford appointment, was a botanical treatise written by Boccone on the plants of the south of Europe, which appeared, edited by him, in 1674. It is interesting from the fact that Morison prefixed to it a dedication to Mr. Hatton, in which he maintained that not only is the propagation of the flowering plants brought about by seed, but that ferns also possess both flowers and seeds.

From the time that Morison was appointed to the Oxford chair he devoted himself to the elaboration of the system of classification which he had already foreshadowed. He proposed to bring it before the world in the form of a History of Plants, and in the leisure which remained to him after the discharge of his university duties

and of the burden of teaching he gave himself assiduously to this task. The book was to bear the title, *Historia Plantarum Universalis Oxoniensis.* He attacked his problem in rather a singular manner, for instead of looking at the outset for large natural divisions, and subsequently sub-dividing them, he adhered without much inquiry to Cæsalpino's division into trees, shrubs, and herbs, exactly as Ray did. This division seems to have exercised a curious fascination for these pioneers of system, fallacious as it shows itself to be on any detailed examination. Morison undertook the detailed work of classifying the herbs in the first instance, postponing the consideration of the arboreal plants till later. He was actuated by the view that the vast number of herbs, and the difficulties of assigning to each its proper diagnostic characters, made them at once the most interesting, the most important, and the most difficult group to deal with. Fearing lest the progress of years and his advancing age might render it impossible to finish his work he preferred to leave the less troublesome group—the arboreal plants—to other hands. His apprehensions, unfortunately, were well-founded, for he was not able to complete much more than half of his projected plan.

It was strange that the first publication which he made of any part of his systematic proposals was not a general sketch of the plan, but a detailed examination or analysis of one of the groups into which he divided the herbaceous plants. It professed to be a specimen of the work, and bore the title, "Plantarum Umbelliferarum Distributio nova, per tabulas cognationis et affinitatis ex libro Naturæ observata et detecta," and was the first monograph devoted exclusively to the systematisation of a single large natural order. In this work the Umbelliferæ were divided into nine tribes, the genera of which were distinguished by the external form of the fruit, or as he held it to be, the seed, assisted in some instances by the form of the leaf. The book was illustrated by 150 figures, which were executed in copper plate. The work indicated boldly the lines on which treatment of the various species then known could be possible, with the view of arranging them on systematic principles, and of showing natural relationship.

In these respects it showed a great advance on anything previously attempted in England. Sachs says of it that it "endeavours to give a clear idea of the systematic relations within the family by the aid of linear arrangement, to some extent the first hint of what we now call a genealogical tree and a proof of

the lively conception which he formed of affinity." It was received both at home and abroad with much appreciation by botanists. This first publication appeared in 1672. The system of classification of herbs to which this was a contribution, did not appear till eight years later. Another curious feature attended its appearance, for the author, ignoring the order of publication of the several volumes of the *Historia*, termed it the second part of that great work. It bore the title, "Plantarum Historiæ Universalis Oxoniensis, Pars secunda; seu Herbarum Distributio nova, per tabulas cognationis et affinitatis, ex libro Naturæ observata et detecta." It was really the only part to appear, but was called *pars secunda* to indicate the postponement of what should have been the first part, that dealing with trees and shrubs. Morison's death prevented the publication of this first part, though there is reason to believe that he had completed it in manuscript.

Morison's system was the following:—

1. Arbores.

Coniferæ semper virentes (most Coniferous genera)
Coniferæ foliis deciduis (*Larix*, *Alnus*, *Betula*)
Glandiferæ (*Quercus*).
Nuciferæ (*Juglans*, *Fagus*, *Corylus*, *Laurus*, etc.)
Pruniferæ (*Prunus*, *Olea*, etc.)
Pomiferæ (*Pyrus*, *Citrus*, *Punica*, *Ficus*, etc.)
Bacciferæ (*Taxus*, *Juniperus*, *Morus*, *Arbutus*, *Sorbus*, etc.)
Siliquosæ (*Cercis* and other leguminous trees)
Fructu membranaceo (*Acer*, *Carpinus*, *Tilia*, *Fraxinus*, *Ulmus*)
Lanigeræ non juliferæ (*Platanus*, *Gossypium*)
Juliferæ et Lanigeræ (*Populus*, *Salix*)
Sui generis Arbor (*Palma*)

2. Frutices.

Nuciferi (*Staphylea*)
Pruniferi (*Cornus*)
Bacciferi, foliis deciduis (*Viburnum*, *Rhus*, *Rosa*, *Ribes*, etc.)
Bacciferi, semper virentes (*Ruscus*, *Myrtus*, *Buxus*, etc.)
Leguminosi (*Genista*, *Cytisus*, *Colutea*)
Binis Loculamentis (*Justicia*, *Syringa*)
Capsulis tetragonis (*Philadelpus*, *Tetragonia*)
Capsulis pentagonis (*Cistus*)
Multicapsulares (*Spiræa*, *Erica*)
Lanigeri (*Salix*, *Tamarix*, *Nerium*)

3. Suffrutices

Scandentes capreolis (*Vitis*, *Bignonia*, *Smilax*)
Scandentes viticulis (*Lonicera*, *Jasminum*, *Solanum*, etc.)
Scandentes radiculis (*Hedera*)

4. Herbæ.

Sectio 1. Scandentes; Bacciferæ (*Bryonia, Tamus*, etc.)
Scandentes; Pomiferæ (most Cucurbitaceæ)
Scandentes; Campanulatæ (Convolvulaceæ)
Sectio 2. Leguminosæ, Papilionaceæ siliquis bivalvibus (Leguminous herbs)
Sectio 3. Siliquosæ tetrapetalæ bicapsulares (Cruciferæ, with *Veronica* and *Polygala*)
Hisce adjiciuntur quædam (*Chelidonium, Fumaria, Epilobium*, etc.)
Sectio 4. Hexapetalæ tricapsulares:
Radicibus fusiformibus (*Asphodelus, Anthericum*)
Radicibus tuberosis (*Crocus, Gladiolus, Iris*)
Radicibus bulbosis (*Narcissus, Hyacinthus, Allium*)
Radicibus squamatis (*Lilium*)
Sectio 5. A numero Capsularum et Petalorum dictæ:
Tricapsulares Campanulatæ (Campanulaceæ)
Tricapsulares pentapetalæ (*Hypericum, Viola*)
Bicapsulares monopetalæ (Scrophulariaceæ)
Quadricapsulares tetrapetalæ (Rutaceæ)
Quinque capsulares pentapetalæ (Geraniaceæ)
Pentapetalæ emollientes (Malvaceæ)
Pentapetalæ unicapsulares (Caryophyllaceæ, Primulaceæ)
Pentapetalæ seminibus triangularibus (Polygonaceæ)
Pentapetalæ seminibus nigris splendentibus (Chenopodiaceæ)
Sectio 6. Corymbiferæ (Compositæ in part)
Floribus aureis (*Artemisia, Tanacetum*)
Floribus rubris (*Adonis annua L.*)
Floribus albis (*Bellis, Anthemis, Achillæa*, etc.)
Floribus ianthinis (*Xeranthemum, Scabiosa, Globularia*)
Sectio 7. Flosculis Stellatis (rest of the Compositæ)
Lactescentes non papposæ (*Cichorium*)
Lactescentes papposæ (*Lactuca, Sonchus, Hieracium*)
Papposæ non lactescentes (*Senecio, Aster, Doronicum*, etc.)
Papposæ Capitalæ (Cynareæ).
Sectio 8. Culmiferæ, seu Calamiferæ (Graminaceæ, Cyperaceæ, Typhaceæ)
Sectio 9. Umbelliferæ:
Hisce adnectuntur Plantæ Stellatæ (Rubiaceæ)
Sectio 10. Tricoccæ Purgatrices (Euphorbiaceæ)
Sectio 11. Monopetalæ Tetracarpæ Galatæ et Verticillatæ (Labiatæ)
Hisce adjiciuntur Galeatæ non Verticellatæ (*Verbena, Euphrasia*), et verticillatæ non galeatæ (*Urtica*).
Sectio 12. Multisiliquæ Polyspermæ et Multicapsulares:
Multisiliquæ (folliculate Ranunculaceæ, *Sedum*, etc.)
Multicapsulares (*Papaver, Nymphæa*, Orchidaceæ, *Aristolochia, Orobanche, Pyrola*, etc.)
Sectio 13. Bacciferæ (some Solanaceæ, *Sambucus, Cornus, Arum*, etc.)
Sectio 14. Capillares Epiphyllospermæ (Filices)
Sectio 15. Heteroclitæ seu Anomalæ (consists of certain Phanerogams, Pteridophyta other than Ferns, Bryophyta, Algæ, Fungi).

The full statement of the method was not published till 1720, when it appeared in a small volume printed at Oxford, under the title of *Historiæ Naturalis Sciagraphia*. From the date of publication this pamphlet appears to have been derived from Bobart's

writings, but it expressed the views of Morison as elaborated and completed by his successor. It was not wholly consistent with Morison's views of classification, for only half the fifteen classes or sections of the herbaceous plants were actually founded on the fruit; several groups were based upon the habit, and some on the inflorescence, while the Papposæ lactiscentes took account also of the qualities of the plants. The last class, Anomalæ, was a flagrant survival of the methods of the herbalists.

The *pars secunda*, really the first volume, dealt with the first five classes only, though the arrangement of the next four also was finished before Morison's death. The *Umbelliferæ* formed the subject of the specimen volume, which had appeared eight years earlier. The publication of the arrangement of the sixth, seventh, and eighth classes was deferred for nineteen years; in the meantime Bobart the younger, who succeeded him as *Horti Præfectus*, completed the discussion of the remainder of the herbaceous plants, and the whole of these groups appeared as the *pars tertia* or second volume of the *Oxford History* in 1699 under Bobart's editorship. It contained also the results of the work of Doody, Petiver, Sloane, Sherard, and others, as well as the records of the *Hortus Malabaricus*. The account of the trees and shrubs saw the light for the first time in the *Historiæ Naturalis Sciagraphia*.

Morison's system was not so well conceived in its broader outlines as that of Ray. Like Cæsalpino he adhered, as did Ray also, to the division of plants into arboreal and herbaceous, the fallacy of which plan had so far not been realised. Unlike Ray he paid no attention to the essential differences between Monocotyledons and Dicotyledons to which the morphological features of the embryo gave a clue even in the absence of histological detail. In many parts it was very satisfactorily worked out, as in the treatment of the Umbelliferæ already mentioned. It showed, however, very little appreciation of affinity on the large scale. Many of his classes contained genera having little or nothing in common. The most different forms were arranged together in their subdivisions, the class Bacciferæ for instance, as Sachs pointed out, containing such dissimilar genera as *Solanum*, *Paris*, *Podophyllum*, *Sambucus*, *Convallaria*, and *Cyclamen*. Though the method was intended to be founded on the character of the fruit it was by no means uniformly so, the last class being little more than a lumber-room. His classes were not numerous enough, and consequently were too crowded, the result being that groups were forced to-

gether which had sufficient individuality to stand out distinctly by themselves. He was often very vague in his diagnostic characters of genera, which were not satisfactory. He frequently departed from his starting point that the characters of the fruit should especially mark genera. Sachs, in his *History of Botany*, condemned the system as inferior to the earlier attempts of L'Obel and of Bauhin.

Morison held the Oxford professorship till his death in 1683. He was the unfortunate victim of a carriage accident in London; he was knocked down by a coach while crossing what is now Trafalgar Square, and survived only twenty-four hours.

CHAPTER XII

MORISON AND RAY CONTRASTED—OXFORD CONTEMPORARIES

It seems inevitable to set up a comparison between Morison and Ray. They were contemporary figures, each almost inimitable in his own way, each living for science and aiding in its advancement with all possible enthusiasm. No doubt each owed something, probably a good deal, to the writings of the other. Yet the verdict of posterity has been that Ray was the greater figure of the two, both as man and as botanist. Morison was the man of the world, somewhat arrogant in his demeanour, self-centred and lonely, a much more isolated figure than Ray. He left but little record of friends and co-workers, with the exception of Bobart, his assistant and successor, and Willisel, who worked with him in the early days at Oxford. As an author the same tendency to self-assertion may be seen. He was a very selfish writer, taking credit in advance for whatever he did without much inquiry as to whether it had been done or hinted at before, and grudging, apparently, to give his predecessors their due credit. This was seen especially in his attitude to the writings of Cæsalpino. As a botanist he had not the breadth of mind of Ray, he could not grasp true principles of fundamental importance. His contemporaries accused him of plagiarism, a charge which, however, seems scarcely just, though he seems to have obtained his conception of natural relationship from Bauhin's *Pinax*. His somewhat arrogant bent of mind is very apparent, when we recall the very unworthy treatment which we have seen he accorded to that great work, quite failing to give adequate recognition to its merits. But this weakness of his was in all probability the result of his early career and the influential connections which he formed both in France and England. Unfortunately, he carried the same spirit into his relations with Ray, though these were not of a very extensive character. We have seen that while he was engaged on his proposals for classification Ray's tables appeared. In the *Præludia Botanica*, in which those proposals saw the light, he alluded very disparagingly to Ray's work, though he did not mention him by name. He made it quite clear, however, to whom he was alluding in the following passage: "Et ego hoc observavi in

multis Authoribus scribentibus aliquot abhinc annis, imo non ita pridem, in Libro quodam ab Authore, vestri Collegii Socio edito, in quo exhibetur methodus, per Tabulas, disponentes classes plantarum, a similitudine foliorum, simplarum. Ego tantum confusum Chaos; illic, de plantis legi, nec quicquam didici, ut monstrabo tibi et lapsus, et confusionem alias." This was not only bitter, but unfair, for Ray's work does not show the reliance on the shape of the leaf which Morison imputes to it. In the *Botanic Essays* written about fifty years later, Dr. Patrick Blair tells us that Morison often attacked Ray in conversation and in his correspondence, accusing him of studying plants "more in his closet than in gardens and fields." This charge seems one that might with greater truth have been urged against Morison by Ray when we consider the work of exploration to which for many years the latter devoted himself, the journeys he made both in England and on the Continent entirely for the purpose of studying the flora. Though supported by Blair, in what appears to be a spirit of blind partisanship, it can only recoil on Morison when a dispassionate examination of the work of both is made.

This spirit of Morison manifested as we have seen, aroused considerable indignation in the breast of Ray and led him to retaliate with much severity. No doubt it must have been the more severely felt as Ray had decided to abandon his cherished scheme of writing his *Historia* when he learned that Morison was engaged on a similar enterprise. It is much to be regretted that Ray like Morison was unjust to his opponent in part of what he said, and in his turn put forward an estimate of the work of the latter, which was neither fair nor generous.

During most of Morison's professorship the custodian of the garden was Jacob Bobart the elder, a distinguished gardener of German extraction. Upon him fell the labour of laying out the grounds and getting all in order, for there is little doubt that Tradescant never carried out any of the duties of the post to which he was said to have been appointed. Bobart was so successful that in 1648 the garden contained some 1600 specimens, including both species and varieties. He published in that year a catalogue of the plants, which ran into a second edition ten years later.

Under his management the garden presented a very formal appearance, the walks being stiff and geometrical, and the trees and shrubs cut into the semblance of mathematical solids, according to the fashion of the time. Bobart died in 1680 and was followed as custodian of the garden by his eldest son, Jacob Bobart the

younger. He seems to have somewhat neglected things and to have done but little to improve the garden, which, however, was said to have contained in 1714 many thousand plants, not only making it very ornamental, but affording ample opportunities for study. It was also well furnished with medicinal plants, ranking in this respect with the best gardens in Europe. Bobart, indeed, was held to have been more a good horticulturist than a scientific botanist.

On the death of Morison, Bobart succeeded to the position of *Horti Præfectus*, though it is uncertain whether he was ever elected by Convocation. The professorship was not filled up, but remained in abeyance for nearly forty years. Bobart had been associated with Morison in the preparation of the *Historia*, and he then became in a sense his literary executor. To him fell the task of completing the work and utilising the materials which Morison had accumulated. The last volume, *Pars Tertia*, published in 1699, is consequently mainly his work. On comparing it with Morison's own it suffers very greatly from the comparison, being very much abridged and compressed, to the great detriment of its style. This is, however, hardly to be wondered at, when the preliminary training of each of the two writers is remembered.

The completion of the *Historia* was Bobart's contribution to science. He published a few memoirs, but they were of little interest, except an Oxford seed-list which found a modest circulation amongst the gardeners of the time.

Bobart seems certainly to have survived Ray, but there is some uncertainty as to the date of his death. He has been said to have been compelled by the then Vice-Chancellor to resign his office in March 1719, and to have died before the end of the year.

During Morison's career at Oxford he had as a contemporary Dr. Robert Plot, who was the first Keeper of the Ashmolean Museum and Professor of Chemistry in the University. Plot was a distinguished man of science and was made secretary to the Royal Society in 1682, being thus a colleague of Oldenburg. His botanical influence lay chiefly in the impetus he gave to the compilation of local floras. He sketched out a plan for a *Natural History of England* to be based on a series of such floras, and with much diligence started to carry it out by working up the plants of Oxfordshire and Staffordshire. Though the scheme was never developed to the extent Plot hoped, contributions to it were made during many years by several botanists, the following floras being published: Lancashire, Cheshire, and the Peak, by Leigh,

1700; Westmorland and Cumberland, by Robinson, 1709; Northamptonshire, by Moreton, 1712; Surrey, by Aubrey, 1719; Cornwall, by Borlace, 1758; Northumberland and Durham, by Wallis, 1769; Westmorland and Cumberland, by Nicholson and Burn, 1777. Plot's successor as Keeper of the Ashmolean Museum, Edward Llhwyd, was also a botanist of some repute. He studied especially the plants of Wales and Cornwall, and published many papers in the *Philosophical Transactions*. He was a friend and correspondent of Ray during the latter part of his life. Writing to him in 1695 he introduces the subject of certain fossil plants or impressions of them which appear to indicate a certain familiarity with a branch of botany which only came into actual prominence much later. "I have sent you here a figure of one of these coal plants, from which and those in Camden you may make some estimate of the rest. I found it in a coal-pit in the forest of Dean together with several others. As 1st, Hart's tongue; 2dly, a kind of Trichomanes; 3dly, *Lonchitis aspera*, called by the workmen Vox Vearn, *i.e.*, Fox Fern; 4thly, a kind of Equisetum which they call Cat's Tail; 5thly, a small Gallium, or Mollugo, with some others which I know not whether to refer. This seems to resemble partly the Osmond Royal, but to me the leaves are too small, too thick set, and round pointed; but I leave you to match it, who are best able." Llhwyd published in the *Philosophical Transactions* a description in Latin of several fossils, which he named *Siliquastra*, *Buofnites*, and *Glossopetræ*.

The botanical work of John Evelyn, the friend of Bishop Wilkins and of Boyle, and the author of the *Diary* should not be forgotten, though he was rather a virtuoso than a man of science. He wrote a work to which he gave the title: "Sylva, or a discourse on Forest trees and the propagation of timber, to which is annexed Pomona, an appendix concerning fruit trees in relation to Cider." Published in 1664 it went through many editions.

CHAPTER XIII

CONTEMPORARY BOTANY IN SCOTLAND

THE study of botany in Scotland originated during the period with which this chapter is concerned. Pulteney, indeed, mentions one or two names of earlier date, but nothing authentic can be traced to them. A certain Ogilby, a Scotsman, flourished about 1470, who is said to have been celebrated for his knowledge of natural history. He left a book *De Balneis*, and another work in six volumes, *De Virtutibus Herbarum*, but his association with Scotland was of the most slender nature. One James Cargill of Aberdeen was a pupil of Kaspar Bauhin and in later life corresponded with him, sending him specimens towards the end of the next century. Cargill is mentioned by L'Obel in terms of commendation in the *Adversaria*. He left no contributions to the literature of botany. Even Morison did little that can be associated with Scotland. As we have seen, his early scientific work was done on the Continent, and after his return to this country he was particularly associated with Oxford.

The rise of botany in Scotland was due almost entirely to the labours of two men, contemporaries and friends, Sir Andrew Balfour and Sir Robert Sibbald. The former of these, some eleven years the senior, was born at Balfour Castle in Fifeshire in 1630, and was an alumnus of the University of St. Andrews, where he took up the study of natural history and medicine. Thence he went to Oxford and later to the Continent, where he spent some years, studying medicine at Paris for part of the time. On his return he spent some little time at St. Andrews, and then removed to Edinburgh, where his scientific work was mainly done. During these years he was an ardent collector of botanical specimens, which later found their way to the botanical garden of the northern metropolis. He had amassed a considerable collection by 1670.

Sir Robert Sibbald was born in Edinburgh in 1641 and was educated at the University, where he studied first theology and later medicine. In 1660 he went to Leyden for a year and took the degree of M.D. there in 1661. His student life was continued at Paris and at Angers, where he graduated in 1662, returning after a short stay in London to Edinburgh where he settled. His career

at Edinburgh was very distinguished; he was largely instrumental in founding the Royal College of Physicians there, the charter being obtained in 1681; in 1682 he was appointed physician to Charles II., and in the same year was made geographer of Scotland, largely through the influence of the Earl of Perth. In 1684 he was elected president of the Royal College of Physicians of Edinburgh, and the next year was made Professor of Medicine in the University, the appointment being in the hands of the town council. A change in his religious views led to his acceptance of the Roman Catholic faith soon afterwards, and he was compelled to leave Edinburgh. He does not seem to have had very firm convictions, for we find him some few years later recanting and returning to Edinburgh. In 1697 he presented to the University his collection of natural history specimens, following the example of his friend Balfour. He died in 1722.

It is with his scientific career that we are especially concerned. Besides minor works on natural history he wrote a large folio under the title, *Scotia illustrata, sive Prodromus Historiæ Naturalis Scotiæ*, which appeared in 1684 and again in 1696. In this he devoted a large section to the indigenous plants of Scotland, treating, as was usual at the time, of their medicinal and economical uses as well as of their more strictly botanical relationships.

But Sibbald was known less by his writings than by his efforts to establish the study of botany on a sound basis in Edinburgh. The main work he did was to create in co-operation with Balfour a botanic garden in the city. In 1667 they obtained a piece of ground belonging to Holyrood, and stocked it with nearly a thousand plants. The effort was on a very modest scale, the new garden measuring only 40 feet in each direction, but such as it was, it amply justified its existence, and proved of great value to the students. A further service which they rendered to botany was the discovery of James Sutherland who was made intendant of the garden in 1676, soon after its formation, and who afterwards became the first professor of the subject in Edinburgh. The whole scheme which afterwards grew to very great proportions may be ascribed jointly to these three men. The success of the garden under Sutherland's management was so conspicuous that a portion of the Royal Garden at Holyrood Palace was a little later set apart for the cultivation of medicinal plants, and the contents of the original plot were transferred to it. This garden or section of a garden at Holyrood became the first botanical garden in Edinburgh, and a professorship being established in connection with it, it

became known as the Royal Physical Garden. Sutherland was made the first professor and was called the Botanist to the King in Scotland, and Keeper of the Garden.

In the year after Sutherland's appointment in 1676 the new departure which had attracted the support of many of the leading physicians of Edinburgh and other men of influence in the city was followed by a movement set up by the town council on behalf of the University. The patronage of the latter was at that time practically in the control of the municipal body and with the view of strengthening the study of medicine the council founded a University Chair of Botany and to provide for practical teaching they ultimately gave the promoters the lease of the gardens belonging to Trinity Hospital, with the adjacent grounds. These remained the centre of botanical study till the time of Hope a century later. This garden was situated in what is now Princes Street, its site coinciding with part of the area now occupied by the Waverley Railway Station.

A little later a third garden was formed nearer the university buildings, on part of the Kirk o' Field, possibly for the greater convenience of the students.

The University Chair was founded in 1695, and was filled by the appointment of Sutherland, who was already the King's Botanist, and no doubt the only person capable of discharging its duties. To him had fallen the duty of laying out and developing all three gardens, a task he discharged with conspicuous success, so much so, indeed, that in 1683 the University garden is said to have contained 3000 species of plants. His own reputation was materially enhanced; prior to the formation of the first garden its intendant had been known only to a few as a youth who, by his own industry, had obtained a great knowledge of plants. When he was appointed to his first post under them, the Town Council gave him a salary of £20 per annum, and a room in the college. He was thus practically at the Head of the Department, if we may so call it, prior to his formal appointment as Professor of Botany in 1695. Probably he did not lecture, but attended in the gardens to give assistance to any who sought instruction in botanical subjects. The College of Surgeons assessed their apprentices a guinea each for such instruction as Sutherland agreed to give.

Prior to this university appointment he published in 1683 a *Catalogus* of the plants growing in the Royal Physical Garden, in which he described them, giving their names in Latin and English. It did not contain many of the native plants with

which, indeed, Sutherland does not seem to have occupied himself. The study of this section of botany was pursued apparently only by Sibbald.

This book was Sutherland's chief contribution to the literature of the subject. He continued to occupy the University Chair for ten years, but gradually fell off in assiduity, cultivating other hobbies, and after a time was complained of as neglecting his duties, both to the apprentices and to the garden. The Town Council took action by reducing his annual salary to £5, whereupon he resigned his office, vacating the Chair in 1705. He retained his post under the crown, continuing as Keeper of the Royal Garden at Holyrood till 1715. His death occurred in 1719, at the age of 80.

This unfortunate separation of the two chairs was not remedied for many years, and Edinburgh consequently possessed two professors and their staffs, with consequent rivalry in teaching, till they were brought together again nearly half-way through the century under Alston.

At Aberdeen, Wallace of King's College was contemporary with Sibbald. He wrote a description of the Islands of Orkney, in which he inserted notes of their botany. The book was published posthumously in 1693. Though Wallace seems to have been influenced in a very great degree by Sibbald, comparatively little progress in botany was made at Aberdeen, no university teaching in the subject being provided.

CHAPTER XIV

VEGETABLE PHYSIOLOGY IN THE SEVENTEENTH CENTURY

Introductory—Hooke

UNDER Ray and Morison and their contemporaries considerable advance towards the systematic arrangement of plants had been made, and the old confusion of the herbalists began to disappear. But the study of botany was not confined to the examination and cataloguing of the flora, though naturally these features were the most closely pursued. The original conception of the vegetable kingdom included speculation on the virtues and properties of plants, which, indeed, the herbalists put almost in the first place. The pursuit of this side of the science not unnaturally led to inquiry into the internal differences of plants, and so to investigation of the means by which they came to live and to be different in various properties from one another. The questions which suggested themselves gained force by the advancement of knowledge of animal physiology and the structure of the animal body, carried out earlier by Vesalius, Servetus, Borelli, and others, and were especially stimulated during the first half of the seventeenth century by the work of Harvey on the circulation. The probability of the existence of some similar mechanism in the plant seized hold of more than one inquirer, and especially the problem whether there was anything in the plant that corresponded to the circulation of the blood in animals. At the time of Ray these questions made themselves felt practically for the first time; nothing had been determined as to structure, indeed, nothing was known clearly of either the anatomy or the physiology of plants.

At about the same time another physiological problem was making its way to the front, connected not with the general problems of vegetable life, but with the interpretation of the flower. Early ideas of the flower in some strange way did not associate it with the function of reproduction, though it was seen to be followed on the plant by the fruit with its accompaniment of seeds. Its connection with the processes of reproduction, and with the idea, presented at first very vaguely, and with great crudeness, that sexuality is possessed by plants may be found to have

originated at about the same period. We find, therefore, that the inquiries into physiological problems took at the outset two lines of development, the one the vegetative, the other the reproductive. The latter, indeed, had the more immediate results of the two. While imperfectly understood, the true working of the parts concerned being altogether misapprehended, it led to the establishment of the so-called sexual system, and the foundation of the artificial system of classification introduced by Linnæus, and known by his name. While at the time we are writing of both these problems were largely matters of speculation, they soon passed from this region into that of experimental inquiry.

Few observations of any kind on the first of these questions can be traced further back than the middle of the century. In 1664 Merret, the author of the *Pinax*, made some experiments on the healing of vegetable tissue after being wounded; he found that if the two exposed surfaces of a cut branch were put in contact, and held so by binding them together, complete union would take place. Not much of an experiment certainly, and hardly worth recording were it not that it is the earliest recorded experiment made in England on the living plant. Merret's work, however, went further than this; he carried out certain researches on the relation of water to the plant, and was led thereby into a somewhat hasty generalisation as to the circulation of the sap. He showed that succulent plants, such as the *Aloe*, were capable of surviving removal from the soil for some years if kept in a moderate temperature, and that they suffered a gradual but continuous loss of weight while so kept. That the plants under experiment were living during this time was shown by the fact that they put out fresh leaves year by year, though they lost some of their older ones. Merret ascertained also that the wilting of fruit, which was sometimes noticeable on a cherry tree, could be avoided by supplying the tree with water at its roots. Somewhat hastily he concluded that his experiments pointed to a "circulation of the juice," an idea which no doubt he, being by profession a physician, based on Harvey's discovery made some forty years before.

This theory of the calculation of the sap found a firm place in the early physiological speculations, and was the centre of prolonged controversy, holding, indeed, its position for a considerable time, not entirely disappearing till the middle of the nineteenth century. The idea was advanced in Germany by Major in 1665, and was the subject of many researches there as well as in England. More than a century later we find Pulteney stating that in the

opinion of the botanists of his time the circulation of the sap was "still probable," the *succus communis* rising from the roots and the *succus proprius* descending to them.

These inquiries were present in the mind of Ray, and, as we have seen, they led him, in 1669, to the prosecution of some researches on the movement of water in the plant, which he published in the fourth volume of the *Philosophical Transactions* in that year. Pulteney says of these experiments that they "proved the ascent and descent as well as the lateral course of the sap," but that Ray and his collaborators "declined giving any decisive opinion as to a real circulation upwards by the vessels of the wood and downwards by those between the wood and the bark, which was the doctrine maintained soon after this time by Grew and Malpighi and indeed afterwards adopted by Mr. Ray himself." Why Ray should give a decisive opinion on a detailed theory which did not appear till "soon afterwards," does not seem very evident. Ray's work appears in a more definite form in the first volume of the *Historia* in 1693. He there speaks of the lymph, by which he meant the ascending sap, as rising in the woody fibres of the trunk, and differing in no noticeable respect from ordinary water. He says that in spring the true vascular elements of the wood are filled with lymph, but that they contain only air in summer, so that the path of the lymph at this period of the year is in the "lymph vessels," that is in the fibres of the wood and the bast. He showed in his experiments that a lateral flow of the lymph in the wood is possible, and that no mechanical arrangements such as valves are present in the vessels to aid in the regulation of the flow, and to prevent an undesirable return. Ray was very explicit on the path of the ascending sap, which he says "doth not only ascend between bark and tree, and in the circles between the several coats of wood, but also through the very body of the wood."

Ray was not the only experimental physiologist of the time in England; researches extending over several years were carried out by Willughby, Beal, Tonge, Woodward, and Lyster. They are published in the early volumes of the *Philosophical Transactions* from 1670 onwards. Little if anything more than Ray discovered resulted from them, but they show how active inquiry of this kind began to be, and how little grip of the physiological problem was evinced by any of the scientific men of the time. The experiments seem to modern workers crude, ill-devised, and likely to result in nothing of any value. We find them quite

at a loss to observe any difference between the respective causes of the exudation of water from a cut tree in the winter and in the spring, between which they did not discriminate. They started with the fallacious assumption that the sap which rises from the roots is the most important factor in all the nutritive processes, though they agreed incidentally that the plant " feeds as well on the air as the juyce furnished through the root."

The last-quoted statement, made by Beal, was indicative of a further physiological conception which was beginning to be entertained, the idea that leaves play a considerable part in the nutritive processes, being concerned in some way with the construction of the food or part of it, though the conception was misty, and not very wide-spread. Even in the time of Hales, in the next century, the idea had proceeded no farther than that the air supplies something nutritive, and so supplements the contributions of the soil.

It may be remarked in passing that Woodward in 1697 first practised the method of water-culture, which later was so efficacious in the hands of Sachs. Woodward was the first Englishman to notice transpiration. Such researches were not confined to England, but were eagerly prosecuted by many noted workers on the Continent. Among them may be mentioned Van Helmont, Malpighi, and Marriotte, names which are very conspicuous in the early history of vegetable physiology. In dealing with the questions of nutrition these investigators were more successful than their English contemporaries, who in the main contented themselves with inquiries into the behaviour of the " sap."

But among the scientific workers in England at that time, there were two men who soon made themselves more conspicuous than the rest in prosecuting inquiries into the structure rather than the working of plants. These were Robert Hooke and Nehemiah Grew, two men who did much to lay the foundation of an accurate knowledge of vegetable anatomy. They differed in essential respects; Hooke was a virtuoso who concerned himself with inquiries into matters connected with every branch of natural knowledge; Grew was a philosopher, painstaking, persevering, reflective, aiming at thoroughness in all he undertook, and sparing neither time nor trouble to arrive at his conclusions. It may, indeed, be held that Grew laid the basis of our knowledge of structure, and took thereby as important a place in structural botany as did his great contemporary, Ray, in the field of taxonomy. The period thus showed two figures which towered above all

others in the pathways of natural history. In its actual results, and the influence it carried, Grew's work probably surpassed Ray's; it was more detailed and more lasting. Ray's largely passed away, and except for some of its broad outlines it left comparatively little trace in the development of the science. Grew's results still stand as the foundation of vegetable anatomy, though much of his work was imperfect and transitory, as we must inevitably expect when we recognise that he knew nothing and discovered nothing of the actual living substance of the vegetable organism. But what he did was sound and lasting as far as it went.

The great outburst of scientific inquiry in England associated with the names of Grew and Ray, was unfortunately doomed to die away with the two great workers themselves. Great and interesting as were the results which they both achieved, these remained, after the close of the century, undeveloped for many years, so far as English workers were concerned. Grew had no successor in the eighteenth century but Hales; Ray stands out as representing English work in taxonomy unapproached till the recent times of the Vegetable Kingdom of Lindley, and later of the great Kew revival.

The conceptions of physiological processes which the physiologists of the time had before them were largely based upon the ancient speculations of Aristotle. While recognising that the food of plants is composed of various substances, he taught that it was all prepared or elaborated in the earth, and was presented to the roots in a condition suitable for nutrition as soon as absorbed. The actual nutrition was considered in some way under the control of a definite soul, the locality of which was generally held to be the pith. As the earth prepared the food the question of its absorption and the nature of the matter absorbed gave an almost overwhelming importance to the sap and its movements after entering the roots. Aristotle's views had been somewhat modified by Cæsalpino, but nothing had been done in the direction of obtaining clearer notions as to the nature of the food. The chemistry of the time was not sufficiently advanced to aid in the elucidation of such questions, and hence the sap as a liquid, rather than the nature of its constituents, was all that was before inquirers. The idea of the supply of any nutritive material from the air had not then dawned, indeed Cæsalpino attributed to the leaves only the function of protecting young shoots and fruits from air and sunshine. As the seventeenth century advanced Jung and Van

Helmont in turn combated some points of the Aristotelian speculation, both arguing against the view of the absorption of all food ready prepared from the soil, and in favour of the carrying out of chemical processes in the body of the plant itself. These objections to the old philosophy, however, had made but little progress when the work of Harvey brought before physiologists the possibility or probability of a circulation of sap comparable to the circulation of the blood. The question of a dominating influence or "soul" at once receded into the background; what it was in the plant that gave the whole organism life, of what kind were the forces that work in the plant during life, these and such like problems attracted neither inquiry nor even attention.

When the pursuit of research into these problems began, it was at the outset altogether physiological, but considerations of the means by which the movements of the sap were brought about led to investigation into structure. The earliest worker who took up such studies seriously and systematically was Robert Hooke, whose "Micrographia, or some Physiological Descriptions of Minute Bodies, made by Magnifying glasses, with Observations and Inquiries thereupon" appeared in 1665. It was a thick folio of some 250 pages, but a very small proportion of it was devoted to plants. Hooke was a type of the philosopher of the time, somewhat, indeed, of a virtuoso, but, nevertheless, an enthusiastic investigator of all branches of natural knowledge. He was born in 1635, and was educated at Westminster and at Christ Church, Oxford. He may be styled at first as an expert chemist, physicist, mechanician, and natural philosopher, and carried out experimental research with so much energy that there was scarcely a discovery made in his day that he did not conceive himself entitled to claim as his own. In 1662 he was made Curator of Experiments to the newly established Royal Society, and his office was made perpetual three years later, when he was granted a salary of £30 per annum, and apartments at Gresham College, Bishopsgate Street, where he resided till his death in 1703. He was made a Fellow of the Royal Society in 1663, and Professor of Geometry in Gresham College in 1665. He succeeded Oldenburg as one of the Secretaries of the Royal Society in 1677, but held the post only till 1682. He numbered among his friends both Robert Boyle and Sir Isaac Newton.

But he was less a botanist than a microscopist and general investigator of Nature. His great work, the *Micrographia*, only

contains thirteen observations which have any connection with plants. They are the following: Observation 16, "Of Charcoal"; Observation 17, "Of Petrify'd Wood"; Observation 18, "Of the pores of Cork and other Bodies"; Observation 19, "Of a Plant growing in the blighted or yellow Specks of Damask Rose-leaves and Bramble-leaves"; Observation 20, "Of Blew Mould and Mushromes"; Observation 21, "Of Moss"; Observation 23, "Of the Form of Seaweed"; Observation 24, "Of the Surfaces of some Leaves"; Observation 25, "Of the Stinging points of Nettles"; Observation 28, "Of the Beard of a wild Oat"; and Observations 29-31, "Of the Seeds of Venice (Venus) Looking-glass, Thyme, Poppy, Purslane, etc."

In 1660 Hooke succeeded in so improving the compound microscope as to give it comparatively clear definition, and a considerable increase in magnifying power. In applying the improved instrument to vegetable substance he seems to have discovered the cellular composition of plants; he examined by transmitted light thin sections of charcoal, which he then compared with cork and other tissues. On cutting "an exceeding thin piece of cork" and placing it on a black object plate, because it was itself a white body, "and casting the light on it with a deep plano-convex glass, I could exceeding plainly perceive it to be all perforated and porous, much like a honey comb, but that the pores of it were not regular." He distinguished then between the hollow spaces (pores) to which he gave the name of "cells," and the separating walls which he called "interstitia." The arrangement of the cork cells in rows led him erroneously to consider them divisions of elongated pores separated by diaphragms.

Hooke went on to explain the physical qualities of cork in the light of his discovery, and estimated the number of pores in a cubic inch of cork to be above twelve hundred millions. "By the transverse constitution of the pores" he came to the conclusion that cork must be the outgrowth from the bark of a tree. Its true nature was not then known in England. He continued, "Nor is this kind of Texture peculiar to Cork only; for upon examination with my Microscope, I have found that the pith of an Elder, or almost any other Tree, the inner pulp or pith of the Cany, hollow stalks of several other Vegetables—as of Fennel, Carrets, Bar-docks, Teasels, Fearn, some Kinds of Reeds etc., have much such a kind of schematisme, as I have lately shown that of Cork, save only that here the pores are rang'd the longways, or

the same ways with the length of the Cane, whereas in Cork they are transverse."

With regard to communication between the cells he wrote, "Though I could not with my Microscope, nor with my breath, nor yet any other way I have ever yet try'd, discover a passage out of one of those cavities into another, yet I cannot thence conclude that therefore there are none such by which the Succus Nutritius or appropriate juices of Vegetables may pass through them; for in several of these Vegetables, whilst green I have with my Microscope plainly enough discover'd these cells fill'd with juices, and by degrees sweating them out; as I have also observed in green Wood all those long Microscopical pores which appear in Charcoal perfectly empty of anything but Air."

There can be no doubt that Hooke appreciated, to a certain extent, the cellular structure of plants; he was the first observer to note it, and he gave a fairly judged account of it. Certainly he did not go far, but what he saw was accurate, and he had some appreciation of its bearings on the physiological problems of the plant.

It would occupy too much of our space to give a resumé of all that the *Micrographia* contains on botanical questions. What has already been advanced will show the general lines of Hooke's work and its interpretation, dealing as it does with his principal discovery.

CHAPTER XV

VEGETABLE PHYSIOLOGY IN THE SEVENTEENTH CENTURY—*continued*

Nehemiah Grew

But the great figure of the time was not Hooke, whose work was not touched at all by the finger of genius, but was more suggestive of the aimless inquiry of the amateur, and lacking entirely in the essential factors of philosophy. A far greater worker was shortly to appear, one possessed of the true philosophic spirit, and endued with the patience and the skill necessary to conduct a research, the results of which have been far-reaching and have endured in the main up to the present time.

Nehemiah Grew, who shares with the great Italian anatomist, Malpighi, the honour of having laid the foundation of vegetable anatomy, was born in 1641, and was educated at Pembroke Hall, Cambridge, where he took his degree as B.A. in 1661. He studied medicine subsequently at Leyden, where he graduated as Doctor of Medicine in 1671. Unlike Ray he led a comparatively uneventful life; by profession a physician, he practised medicine at Coventry and subsequently in London, where he continued till his death, occupying himself with his professional duties and with scientific research. He was made a Fellow of the Royal Society in November 1671, and was chosen joint secretary with Hooke in 1677, after the death of Oldenburg. He was made an honorary Fellow of the College of Surgeons in 1680. He died suddenly in 1712.

A perusal of his great work on the *Anatomy of Plants* shows that he was in the first instance a physiologist and was led to the study of anatomy with the object of elucidating physiological problems. In the "Idea of a Philosophical History of Plants," which serves as an introduction to the book, he set out the plan he put before himself, viz. to inquire: "First by what means it is that a Plant in any Part of it comes to Grow, a Seed to put forth a Root and Trunk; and this, all the other Parts to the Seed again; and all these being formed, by continual Nutrition still to be increased. How the Aliment by which a Plant is fed is duly prepared in

its several Parts; which way it is conveyed unto them; and in what manner it is assimilated to their respective Natures in them all. . . . Then to inquire, What should be the reason of their various Motions; that the Root should descend; . . . That the Trunk doth ascend . . .; and of divers other Motions, as they are observable in the Roots, Trunks, and other Parts of Plants. . . . Further, what may be the Causes as of the Seasons of their Growth; so of the Periods of their Lives. . . . Then as they pass through these several Seasons of their Lives, in what manner their convenient feeding, housing, cloathing or protection otherwise, is contrived . . . And lastly, what care is taken, not only for themselves, but for their Posterity; in what manner the Seed is prepared, formed and fitted for Propagation." He turns then to questions of more internal and special physiology. "Since All, or Most, seem to grow in the same manner, with one Sun, one Rain, indifferently well upon one Soil, and, to outward appearance, to have the same Common Parts; it may be asked, How it comes to pass, that their Liquors, or other Contained Parts are of such different Kinds; one being Watry, another Winy, a third Oily, a fourth Milky, and the like. How also there is such a variety in their Sensible Qualities, as their Colours, Tastes, and Smells; what those Materials are which are necessary to the Being of these Qualities; and those Formalities, wherein their Essence doth consist; as what it is that makes a Plant, or Flower, to be white or red; fragrant or fetid; bitter or sweet; or to be of any other Colour, Smell, or Taste. In like manner their Faculties and Powers, what that is, or those things are, by which they are constituted; as whence one becomes Purgative, another Vomitory, a third Diaphoretik, etc."

We can admire the clearness with which he put the problems of physiology before him. They are stated as clearly as they could have been 200 years later, so far as the main propositions go, but he did not grasp the course of procedure necessary for his purpose. It was with a view to solve such problems that Grew undertook his great work, but he unfortunately was not in possession of a true appreciation of the idea that has done so much in later times to elucidate the meaning of anatomical detail, the view that physiological need is the clue to morphological and histological structure. Rather he proceeded to study the latter, in order that he might discover something of the former, an inversion of the true order, whereby he was led to erroneous conclusions in many cases as to the very points he set out to investigate. He says,

indeed, that "When upon the Dissection of Vegetables, we see so great a difference in them, that not only their Outward Figures, but also their Inward Structure, is so elegant; and in all, so Various, it must needs lead us to Think, That these Inward Varieties, were either to no End; or if they were, we must assign to what." In the absence of any knowledge of the nature of the vegetable processes it was extremely unlikely that an investigation of the details of the plant's interior parts, at that time also absolutely unknown, would throw light upon the problems that were presenting themselves to him. We shall see shortly how the course of the investigation proceeded, and to what extent Grew was successful. There is no doubt, however, that his views were greatly in advance of the current thought of the time,—indeed he may be said to have started the science of vegetable physiology. He went, indeed, so far in his realisation of the importance of its problems that he entertained hopes that physiology would help in classification, a hope which was doomed to fail, being based upon adjustment to surroundings, a mark of ultimate adaptation and not of phylogenetic relation.

Grew said in the preface to his great work that he was led to undertake the study of vegetable anatomy as early as 1664, "considering that both plants and animals came at first out of the same hand, and were therefore the contrivances of the same wisdom." He inferred, somewhat too literally, the "probable analogy of their structures." He had but little preparation for the study, but he was acquainted with Highmore's work in his book on generation, Sharrock on the propagation of plants, and soon afterwards Hooke's *Micrographia*, which appeared the following year. He pursued his task with assiduity, and in 1670 he was able to throw his first results into the form of an essay entitled *The Anatomy of Plants Begun.* He submitted this essay, as he had done a first sketch of it two years before, to his brother-in-law, Dr. Henry Sampson, who brought it before the notice of Oldenburg, the Secretary of the Royal Society. Oldenburg handed it over to the critical scrutiny of Bishop Wilkins, the friend of Ray and author of the *Real Character*, and it was read by him at a meeting of the Royal Society in 1670. It met with the cordial approval of the Fellows, who on May 11, 1671, ordered it to be printed, which was done without delay.

The subject of the anatomy and physiology of plants practically simultaneously attracted the attention of Malpighi in Italy, and he somewhat strangely selected the Royal Society of London to

receive his communication. The result has been to stir up among men of science a controversy as to the relative claims of the two anatomists to priority, the question which of all others in the world of science has perhaps been the greatest provoker of strife. It is very gratifying to be able to say that in this case no disputing of the kind was occasioned. Both writers were animated by a more truly scientific spirit, and each hailed the work of the other with sympathy and appreciation. There is little doubt, however, that Grew was first in the field, but as of course Malpighi's researches were carried out independently and with no knowledge of Grew's results, Malpighi is entitled to no less credit than if he had been first to see his results in print. As we have seen, Grew's earliest essay was before the Royal Society in May 1671, having been read to them the year before. The whole of the first book, after being printed, was presented to the same society in December 1671. By a strange coincidence an abstract of Malpighi's first manuscript was read also at this meeting. As Grew's book was prefaced by a letter written to Bishop Wilkins under date June 10, 1671, it was undoubtedly in print when Malpighi's paper was received only in manuscript, bearing the date November 1671.

The singular modesty which characterised Grew, combined with appreciation of Malpighi's work, led the former to wish to cease his researches and leave the investigation to his Italian rival, but the Royal Society pressed him to continue them, and on April 18, 1672, he was appointed Curator to the Royal Society for the Anatomy of Plants, proposals to that end having previously been brought forward and sanctioned by the Council. Grew wrote very appreciatively about it, showing no jealousy of Malpighi, but cordially endorsing and recognising his work. "This they might be induced to do; upon considering, that it would be no disadvantage to the credit of those matters, which were so new and strange, to be offered to the World from a double authority. For one, although he may have no mind to deceive; yet it is more likely for one, than for two, to be deceived. Likewise, that the same Subject, being prosecuted by two Hands, would be the more illustrated by the different Examples produced by both. And that, as in other matters, so here, the defects of both, would mutually be supplied." Malpighi displayed an equally courteous spirit, and had Grew's work translated into Latin for his private use.

The second and third parts of Grew's work were read to the Royal Society in a series of papers between May 1672, and April 1674. Malpighi's second part was communicated in August 1674.

The first three parts of Grew's work, published as already stated, dealt with the structure of the axis of the plant. He then took up the study of flowers, fruits, and seeds, and communicated his results, which were much less complete, in 1676 and 1677. He proposed to have completed his work by examining what he called "imperfect, parasitical, marine, and sensitive plants," and to have carried out in detail the comparison of the plant and the animal, but he did not complete his projected task. The essays which appeared between the years 1672 and 1682 were published in the latter year in one volume under the title of "The Anatomy of Plants, with an Idea of a Philosophical History of Plants, and several other Lectures read before the Royal Society."

In developing the plan of inquiry which Grew set before himself he proposed to study the forms of plants. "Whatever is of more External Consideration, as the Figures, Proportions, Motions, Seasons, Situations of Vegetables, and of their several Parts, should be observed. In doing which, a particular survey of all their Varieties should be taken. And then a Comparison made betwixt these, and the several Plants or Parts of Plants, whereof they are the Properties. . . . By thus comparing of them, we shall be able more exactly to state the Orders and Degrees of their Affinities; Better to understand both the Causes and Ends of their Varieties: And more probably to conjecture of their Natures and Vertues." In carrying out this part of his inquiries much of his work, especially that on the varieties of the stem, run very much on the lines of modern opinion. He next considered the internal structure, "To go through all the Parts with equal care; examining the Root, Trunk, Branch, Leaf, Flower, Fruit, and Seed . . . To observe divers . . . as to their Interiour Structure: and to make this comparison, throughout all their Parts and Properties. . . . And to do all this by several Ways of Section, Oblique, Perpendicular, and Transverse; all three being requisite if not to Observe yet the better to Comprehend, some Things. And it will be convenient sometimes to Break, Tear, or otherwise Divide, without a Section. Together with the Knife it will be necessary to join the Microscope; and to examine all the Parts and every Way in the use of That." Thirdly, he proposed to study the contents of the plants: "for our better understanding both of the Nature of Vegetation, and of the said Contained Parts. And to make inquiry, First of their Kinds; as Spirits . . . Aers and Vapours . . . Lymphas, or clear and watry Saps . . . Mucilages . . . Oyles . . . Gumms or Resines . . . Milks," investigating not only the characters of

these liquids, but the receptacles in which they are contained, their motions and relative quantities, with such individual features as they possessed. To these sections of his plan he attached very considerable importance. In the fourth place he put the investigation of their solid and mineral contents and the nature of the former as far as could be ascertained. This section of the inquiry seemed to him less favourable than the first three. He said apprehensively : " I know it will be difficult to make observations of this kind upon the Organical Parts of Plants, severally." Lastly, Grew proposed an inquiry into absorption from the soil, the water, the air, the nature of the materials absorbed, and generally the relation of the plant to its environment.

Grew did not shut his eyes to the fact that his problem was difficult, his work arduous, and probably to some extent disappointing. He concluded his introduction with an appreciation of his task and with the expression of a hope that he might be helped in his task by guidance from a higher power. " This is the Design, and these the Means I propose in order thereunto. To which, I suppose, they may all appear to be necessary. For what we obtain of Nature, we must not do it by commanding, but by courting of Her. Those that woo Her, may possibly have her for their Wife ; but she is not so common, as to prostitute herself to the best-behaved Wit, which only practiseth upon itself, and is not applied to Her. I mean, that where ever Men will go beyond Phansie and Imagination, depending upon the conduct of Divine Wisdom, they must Labour, Hope and Persevere. And as the Means propounded, are all necessary, so they may, in some measure, prove effectual. How far, I promise not ; the Way is long and dark . . . the Way of Nature, is so impervious, and, as I may say, down Hill and up Hill, that how far soever we go, yet the surmounting of one difficulty, is wont still to give us the prospect of another. . . . To conclude, If but little should be effected, yet to design more, can do us no harm : For though a Man shall never be able to hit Stars by shooting at them ; yet he shall come much nearer to them, than another that throws at Apples."

Upon this basis and with this design before him, Grew set about his task. He began his researches with the dissection of seeds, both at rest and in a condition of germination. At the outset he said that after an anatomical analysis of all parts of a plant he had certainly found that in all plants " there are two and only two organical parts essentially distinct, viz. the *pithy* part and the *lignous* part, or such others as are analogous to either of

these." In the seed the first of these was represented by the *parenchyma*, covered by a *cuticle*. The word parenchyma thus introduced by him was not used as a histological term, its present interpretation, but indicated a physiological tissue. This parenchyma contained an "inner body" which was the ligneous part, and which from his figures was evidently the fibro-vascular system of the seed. He was able to follow out the anatomical changes incident to germination, but his conception of the physiology of the process was worthless. He said: "The General Cause of the growth of a Bean, or other seed, is Fermentation. That is, the Bean lying in the Mould, and a moderate access of some moisture, partly dissimilar, and partly congenerous, being made, a gentle Fermentation thence ariseth. By which, the Bean swelling, and the sap still encreasing, and the Bean continuing still to swell, the work thus proceeds: as is the usual way of explicating. But that there is simply a Fermentation, and so a sufficient supply of Sap is not enough: but that this Fermentation, and the sap wherein 'tis made, should be under a various Government, by divers Parts thereto subservient, is also requisite." This idea of the dependence of all internal processes of growth and other change upon the sap runs through all the physiological speculations of the time. No idea of a living substance, constituting a definite part of the organism, can be traced in any of them.

Grew went on next to examine the root. He saw in it after dissection a skin, derived from the cuticle of the seed, and a cortical body "which is commonly called the Barque" to which the parenchyma of the seed gave rise. In the centre lay the ligneous body, which from his sketches was roughly the vascular system. His sketches or figures show its distribution and general characters with considerable accuracy. In his pithy part or cortical body he recognised a porous character, the pores being "innumerable and "extream small." He evidently saw the constituent cells without recognising their nature. He spoke of the relations of the cortex and the vascular strand, saying: "the Cortical Body doth not only environ the Lignous, but is also wedg'd and, in many Pieces inserted into it; and that the said inserted Pieces make not a meer Indenture, but transmit and shoot themselves quite through as far as the Pith." Recognising the distribution of the tissues he was quite unable to explain it, or to state it correctly, though his description was consistent with the appearances. Lastly, he described the central pith, which he found only occasionally present. When it could be seen he spoke of it as

communicating with the bark by the insertions. The latter were evidently the medullary rays of present-day nomenclature.

While we can admire the clearness with which Grew appreciated and depicted the anatomical features of the root, we must recognise how fallacious was his idea of deducing therefrom its physiological functions. As a specimen of the most advanced speculations of his day it may be well to quote what he said as to the latter.[1] "I say then, That the *Radicle* being impregnate, and shot into the Moulds, the contiguous moisture, by the *Cortical Body*, being a Body laxe and Spongy, is easily admitted: Yet not all indiscriminately, but that which is more adapted to pass through the surrounding *Cuticle*. Which transient Sap, though it thus becomes fine, yet is not simple; but a mixture of *Particles*, both in respect of those originally in the *Root*, and amongst themselves, somewhat heterogeneous. And being lodg'd in the *Cortical Body* moderately laxe, and of a Circular form; the effect will be an easie Fermentation. The *Sap* fermenting, a separation of *Parts* will follow; some whereof will be impacted to the Circumference of the *Cortical Body*, whence the *Cuticle* becomes a *Skin;* as we see in the growing of the Coats of Cheeses, of the Skin over divers Liquors, and the like. Whereupon the *Sap* passing into the *Cortical Body*, through this as through a *Manica Hippocratis*, is still more finely filtred. With which *Sap*, the *Cortical Body* being dilated as far as its *Tone*, without a solution of Continuity, will bear; and the supply of the *Sap* still renew'd: the purest part, as most apt and ready, recedes, with its due *Tinctures*, from the said *Cortical Body*, to all the parts of the *Lignous;* both those mixed with the *Barque*, and those lying within it. Which *Lignous Body* likewise super-inducing its own proper *Tinctures* into the said *Sap;* 'tis now to its highest preparation wrought up, and becomes (as they speak of that of an Animal) the Vegetative *Ros* or *Cambium;* the noblest part whereof is at last coagulated in, and assimilated to the like substance with the said *Lignous Body*. The remainder, though not united to it, yet tinctur'd therein, thus retreats, that is, by the continual appulse of the *Sap*, it is in part carried off into the *Cortical Body* back again, the *Sap* whereof it now tinctures into good *Aliment*. So that whereas before, the *Cortical Body* was only relaxed in its Parts, and so dilated; 'tis now increas'd in real quantity or number of parts, and so is truly nourish'd. And the *Cortical Body* being saturated with so much of this Vital *Sap* as serves itself; and the second Remainders

[1] *Anatomy of Plants*, Book i. § 23, p. 14.

discharged thence to the *Skin;* this also is nourish'd and augmented therewith. So that as in an *Animal Body* there is no instauration or growth of Parts made by the *Bloud* only, but the *Nervous Spirit* is also thereunto assistant; so it is here: the *Sap* prepared in the *Cortical Body*, is as the *Bloud*, and that part thereof prepared by the *Lignous*, is as the *Nervous Spirit;* which partly becoming Nutriment to itself, and partly being discharged back into the *Cortical Body*, and diffusing its Tincture through the *Sap* there, that to the said *Cortical Body* and *Skin*, becomes also true Nutriment, and so they all now grow."

Grew accounted for the downward growth of the root by assuming particular tendencies in its several parts, into which he did not set himself to inquire. His reasoning was curious as will appear from the following passage:[1] "We suppose therefore, that as the principal motion of the *Lignous Body* is in length, so is its *proper tendency* also to *Ascend.* But being much exceeded both in Compass and Quantity by the *Cortical*, as in the smaller parts of the *Root* it is; it must needs therefore be overborn and governed by it; and so, though not lose its motion, yet make it that way wherein the *Cortical Body* may be more obedient to it; which will be by descent." The Pith was to him for the "better Advancement of the *Sap*," or for the "quicker and higher Fermentation" of the latter. It was thus the more important or superior constituent of the root. "As the *skin* is the Fence of the *Cortical Body*, and that of the *Lignous;* so is the *Lignous* again a far more pre-eminent one unto the *Pith;* the *Sap* being here a brisk Liquor, *tunn'd* up as in a wooden *Cask.*"

Grew treated the Trunk in a similar way, recognising the same parts, skin, cortical body, ligneous body, insertions, and pith. In the older trunks he saw the annual rings more conspicuously marked out than in the root. He described the structure of the wood more minutely than before, saying that the lignified part "is nothing else but a cluster of innumerable and most extraordinary small vessels or concave fibres." He inquired into the nature of the connection between the ligneous and the cortical bodies with their insertions, and held the relation of the one to the other to be such an incorporation as might be compared to the warp and the woof of a cloth; "mutually traced and interwoven together, they thus constitute one strong and firmly coherent body." He found nothing corresponding to valves in the pores or vessels, to regulate the flow of sap. The structure of the pith

[1] *Anatomy of Plants*, Book i. § 23, p. 16.

appeared to him to be that of a honeycomb, the pith not being as Hooke had said " an heap of Bubbles," but he added " in regard they are not fluid but fixed parts. I shall, therefore, choose rather to call them bladders."

Grew speculated with more justice as to the reasons for the distribution of the lignous elements among the softer cortical body and its insertions. In this respect his observations were shrewd, so much so that he appears to a considerable extent a forerunner of Schwendener some 200 years later. He had a fairly clear conception of the reasons for the difference in the distribution of the vascular bundles in the stem and root. He had fairly accurate views as to the secondary thickening of stems and the characters of the annual rings of wood.

In speaking of the functions of the trunk the same idea of the fermentation of the sap meets us. To this process all the parts were conducive in some form or other.

Grew, like all his successors, both physiologists and anatomists, found himself confronted with the problem of the ascent of the sap. He accounted for it by mutual action and reaction between the ligneous body and the pith, but seemed to regard capillarity as the main force at work.

Though accurate in his general sketch of the anatomy of the dicotyledonous tree, Grew was mistaken in his account of the development of the branches. He held that they start from a local outward push of the sap from the pith, which drives the wood outwards, and so an outgrowth is forced through the insertions or gaps in the ligneous body, causing a protrusion of the cortex of the skin, " which is subsequently prolonged after the fashion of a prospective glass." He noted the position of the new branch in the axil of a leaf ; and saw that the branches of the root differed from those of the stem in arising endogenously.

Grew held the function of the leaf to be primarily protective. " The Uses of the Leaves, I mean in respect of their service to the Plant itself, are these: First, for Protection; which, besides what they give one to another, they afford also to the Flower and Fruit." But he thought it discharged other duties in connection with those weird processes—the various fermentations of the sap. In relation to these the leaf rather deprived the sap of undesirable constituents, " its grosser parts," than added anything nutritive. Its purpose in such purification was in his view to send on elaborate and essential parts, particularly odours, to the flowers. A third function he held to be to serve for augmentation or increase of

size of the plant, to receive supplies of sap and prevent its stagnation in the other parts.

In his first paper Grew was very reticent about the flower. He distinguished in the latter the " empalement " (calyx), the " Foliation " (corolla) and the " Attire," but he was very obscure in his treatment of the latter, the meaning and importance of which he had not apparently then grasped. He did not keep distinct the stamens and the carpels, nor did he appreciate the relation of the flower to the fruit. He described, however, the structure of the ovule and of the seed to which it gives origin with great accuracy, pointing out the double integument, the foramen (micropyle) and the position of the embryo within the coats. At the end of his description of the seed, which was very detailed so far as its grosser features are concerned, he maintained his view that there are only two organically essentially distinct parts. " So that all the *Parts* of a *Vegetable*, the *Root, Trunk, Branch, Leaf, Flower, Fruit,* and *Seed*, are still made up of *Two* substantially different Bodies. And as every Part hath *Two*, so the whole *Vegetable* taken together is a composition of *Two* only, and no more: All properly *Woody Parts, Strings* and *Fibers* are one body: All simple *Barques, Piths, Parenchymas* and *Pulps*, and as to their substantial Nature, *Pith* and *Skins* likewise, all but *One Body*: the several *Parts* of a *Vegetable* all differing from each other, only by the various *Proportions* and *Mixtures*, and variated *Pores* and *Structure* of these *Two Bodies*."

Though his idea of the structures was not quite what is the present-day view, we cannot but feel that his generalisation was wonderful for the time, and worked out with great care and skill.

When we pass to consider Grew's more minute anatomical work, we find that instead of starting with the individual cell and then proceeding to discuss the histology of tissues after the fashion of modern phytotomists, he dealt only incidentally with the structure of the cell, the fibre, and the vessel. Still his observations on the union of cells with one another, and on the structure of fibres and vessels, scattered and incidental as they were, form the basis of the investigations of later histologists.

From the observation of shrivelled masses of tissue, Grew came to the conclusion that all the cell-walls, including those of the parenchyma, compose an artificial web of very fine threads. He said: " The most unfeigned and proper resemblance we can at present make of the whole *Body* of a *Plant*, is, To a piece of fine *Bone-Lace*, when the women are working it upon the *Cushion*;

For the *Pith, Insertions,* and *Parenchyma* of the *Barque,* are all extream Fine and Perfect Lace-work: the *Fibres* of the *Pith* running *Horizontally,* as do the *Threds* in a Piece of *Lace;* and bounding the several *Bladders* of the *Pith* and *Barque,* as the *Threds* do the several *Holes* of the *Lace;* and making up the *Insertions* without *Bladders,* or with very small ones, as the same *Threds* likewise do the *close* Parts of the *Lace,* which they call the *Cloth-work.* And lastly, both the *Lignous* and *Aer-Vessels,* stand all *Perpendicular,* and so cross to the *Horizontal Fibres* of all the said *Parenchymatous* Parts; even as in a Piece of *Lace* upon the *Cushion,* the *Pins* do to the *Threds.* The *Pins* being also conceived to be *Tubular,* and prolonged to any length; and the same Lace-work to be wrought many Thousands of times over and over again, to any thickness or hight, according to the hight of any *Plant.* And this is the true *Texture* of a Plant; and the *general composure,* not only of a *Branch,* but of all other *Parts* from the *Seed* to the *Seed.*"

Of the Parenchyma Grew said: "The Microscope . . . more precisely shews, That these *Pores* are all, in a manner, Spherical, in most *Plants;* and this *Part,* an infinite Mass of little *Cells* or *Bladders.* The sides of none of them, are Visibly pervious from one into another; but each is bounded within itself. So that the *Parenchyma* of the *Barque,* is much the same thing, as to its Conformation, which the Froth of *Beer* or *Eggs* is. as a fluid, or a piece of fine *Manchet,* as a fixed Body. The sides also of these *Bladders* are as transparent, as those of Water; or the bodies of some Insects."

This passage makes it less difficult to understand Grew's view of the structure of spiral vessels. He said: "By the *Weftage* of *Fibres,* it is, That the *Vessels,* oftentimes, unroave in the form of a *Plate.* As if we should imagine a piece of fine narrow *Ribband,* to be woun'd, spirally, and Edg to Edg, round about a Stick; and so, the Stick being drawn out, the Ribband to be left in the Figure of a Tube, answerable to an Aer-Vessel. For that which, upon the *unroaving* of the *Vessel,* seems to be a *Plate,* or one single *Piece,* is, as it were, a *Natural Ribband,* consisting of several Pieces, that is, a certain number of *Threds* or *Round Fibres,* standing parallel, as the *Threds* do in an *Artificial Ribband.* And as in a *Ribband,* so here, the *Fibres* which make the *Warp,* and which are Spirally continu'd; although they run parallel, yet are not coallescent; but conteined together, by other *Transverse Fibres* in the place of a *Woof.*" True spiral vessels with separable spiral threads of thickening matter were thus left undistinguished from vessels

occurring in secondary wood, which only show their spiral structure on being torn. Grew noticed, however, that the wall of a trachæal tube may be formed by two or more spiral bands, and that the tracheæ are never branched, and, further, he recognised that such vessels are formed by the fusion of cells.

In common with Malpighi, Grew held that the young layers of wood in the stem originate from the transformation of the innermost layers of the rind. He said: "The *Wood* is likewise compounded of Two Sorts of *Bodies;* That which is strictly *Woody;* and the *Aer-Vessels* mixed herewith. The true *Wood* is nothing else but a mass of antiquated *Lymphæducts*, viz., those which were originally placed on the inner Margin of the *Barque*. For in that place, there grows, every year, a new *Ring* of *Lymphæducts*. Which losing its original softness by degrees, at the latter end of the year, is turned into a dry and hard *Ring* of perfect *Wood*."

By "strictly woody" substance Grew meant the fibrous components of the wood, excluding the vessels containing air, while his "Lymphæducts" appear to have been the bast fibres, etc., for he went on to say: "The *Aer-Vessels*, with the *Insertions*" (the medullary rays) "and true *Wood*, altogether make up That which is commonly called, the *Wood* of a *Tree*. The *Aer-vessels* I so call, not in that they never contain any Liquor; but, because all the principal time of the growth of a *Plant*, when the *Vessels* of the *Barque* are filled with *Liquor*, these are filled only with a *Vegetable Aer*." But it is impossible to quote at greater length the observations Grew made upon the internal anatomy. His work upon the axis of the plant and its branches was extremely careful, complete, and, for the time, thorough. It was richly illustrated by careful drawings of sections of various trunks and other parts which will bear comparison with the illustrations of the present time. He was less successful with leaves, though he examined them with care and skill, but his ignorance of their function led him to ascribe wrong values to their different parts. Still his representations of their forms and his speculations as to the causes of such forms as he found are still worthy of attention. As an instance of the closeness of his observation we may quote the following: "For upon breaking the *Stalk* or chief *Fibers* of a *Leaf;* the likeness of a fine *Woolly* Substance, or rather of curious small *Cobwebs*, may be seen to hang at both the broken Ends. . . . Now this fine *Wool*, is really a *Skein* of *Aer-Vessels*, or rather of the *Fibers* of the *Aer Vessels*, unroaved from their *Spiral Position*, and so drawn out in Length." This might have been written to-day. On the

anatomy of the parts of the flower Grew made no observations. He was interested in the function of its members, as we shall see later, but he did not treat it as he did the vegetative structures of the plant.

It is noteworthy that Grew found himself in conflict with Ray on the question of the occurrence of buds on herbaceous plants. After speaking of the formation of these structures on trees he went on: "And so in *Herbs;* as the *Flower* of *Asarum* which appeareth in *April* or *May*, is entirely formed in *August* or *July* of the foregoing year. For there are here, as well as in *Trees*, Two Sorts of Buds; some which are composed only of *Green Leaves;* and some which also contain a *Flower*, and the *Seed Case*." His observations on buds included a study of the principles of vernation or the arrangement of their leaves; also of the mechanisms connected with their protection.

At the conclusion of his discussion of the flower, Grew gave expression to the view that the preferable system of classification would be one based upon the structure or variety of the flower supplemented by the varieties of the leaf.

We have seen how Grew thought it would be possible to infer the nature of physiological processes from an acquaintance with the structure of the parts concerned. He was not, however, satisfied with speculations on these lines, but made experiments to settle various points, chiefly concerned with the movements of the sap. He ascertained that the path of the ascending fluid is the wood, for he found that when bleeding occurs on cutting a stem in March and April, the water can be squeezed out of every ring in the young twig from the outermost to the centre, but that none can be expressed from the bark. He denied, therefore, the view current at the time that the sap rises between the wood and the bark. But he thought the path he traced was only taken in the spring, and that "for the greater part of the year, it riseth in the *Barque*, sc. in the inner Margin adjacent to the *Wood*, and in the Spring, in or through the *Wood* itself, and there only." In one particular he made an important suggestion which, though for a time lost sight of, ultimately came into prominence, and maintains its place to-day; he attributed the rise of the sap mainly to the lateral pressure of the turgid parenchyma, an idea in which we can recognise the germ of the theory of root pressure. The sap is forced up each vessel or pipe by capillarity combined with this pressure. "And the said *Pipe* or *Vessel* being all along surrounded by the like *Bladders*" (turgid cells of the parenchyma);

"the *Sap* therein, is still forced higher and higher; the *Bladders* of the *Parenchyma* being, as is said, so many *Cisterns* of *Liquor*, which transfuse their repeated Supplies throughout the length of the *Pipe*."

Grew knew that the green colour of a plant depended upon its exposure to access of air, and speculated on why this was the case. He was here near the truth; had he realised it was the light which is admitted with the air which is concerned he had made a still greater discovery. He was, however, led quite away from the truth by noticing that many vegetable juices are turned green by the action of alkalies; he concluded that there was some alkaline constituent of air which normally produced the colour. He seems to have seen the chlorophyll granules, for he spoke of the air acting on "the acid and sulphurous parts of plants for the Production of their *Verdure;* that is they strike altogether into a *Green Precipitate*."

Grew had possession of the fact or the discovery that the air is of further use to the plant as contributing to its nutrition, though his ideas were very indefinite. Impressed as he was that the body of the plant must be based on similar lines to that of an animal, an idea which comes into great prominence in his dealings with the flowers, he said, "Every plant hath Bowels of divers kinds, containing divers kinds of liquors. That even a plant lives partly on air, for the reception whereof it hath those parts which are answerable to Lungs." He thought that the air was absorbed by the roots and passed through the "insertions" into the vessels of the root and stem and thence to the pith, being subsequently circulated in the plant by means of these vessels and insertions.

He failed to realise the sensitivity of plants, but he noticed the occurrence of tropisms, and saw that they are not to be explained on mechanical grounds alone. This is seen especially in his remarks upon geotropism; he claims that the different directions of growth of shoot and root are attributable to differences in their nature.

Reference has already been made to Ray's physiological experiments and his teaching as to the movements of the sap in plants. These, however, did not represent the sum total of his knowledge of the vital processes. Many of the questions which have received explanation only during comparatively recent years had attracted his attention, though his speculations upon them did not greatly aid their elucidation. He attempted to

explain what he saw by the application of physical laws, but his ideas were largely influenced by the opinions of Jung, whose disciple, in a sense, he was. Jung had said, "Planta est corpus vivens, non sentiens," an old error reproduced much later by Linnæus. Impressed with this dictum Ray, like Grew, missed the great phenomena of sensitiveness, a mistake shared, however, by all the observers of his time. His explanations of various phenomena consequently appear hopelessly inadequate. He dealt in his *Historia* with many of the movements of plants, and explained them all on mechanical principles, even the dropping of the leaves and leaflets of *Mimosa* when touched; he was not clear on the difference between the so-called automatic or periodical movements and those due to stimulation. He thought heliotropic curvatures were due to disturbance of growth owing to differences of temperature on the two sides of the curving organ, the colder growing more slowly. He was acquainted with the phenomena of transpiration, or at any rate of evaporation from the leaves of water passing to them from the stem. He attributed the opening and closing of flowers to variations of temperature, and applied the same idea to the nyctitropic movements, while he thought that cooling acted on *Mimosa* as a touch. While he was familiar with the phenomena of etiolation, he thought the great extension of the axis of the plant was to be attributed to its seeking warmth and not light.

He was in advance of Grew in his appreciation of the fact that the development of the green colouring matter depends not so much on air as on light, for he said that "plants became green under glass and not under an opaque cover."

Leeuwenhoek.

Anatomical study owes something also to the researches of Anton von Leeuwenhoek, who, though not an Englishman, contributed the accounts of his researches to the Royal Society. With the aid of glasses of higher magnifying power than those possessed by Malpighi and Grew he succeeded in discovering the pitted vessels of secondary wood, and was the first to perceive crystals in vegetable tissues; his studies of plants were, however, very empirical.

CHAPTER XVI

VEGETABLE PHYSIOLOGY IN THE SEVENTEENTH CENTURY —*continued*

The sexuality of Plants

The second line of physiological inquiry was concerned with the interpretation of the structure of the flower, and led immediately to the discovery of the process of pollination with its ultimate results.

It was no new subject of speculation, for it presented itself to the old Greek philosophers, as we find from Aristotle, though his ideas on the subject were of the vaguest. His disciple, Theophrastus, mentions as a matter of common knowledge that the fruit of the date-palm does not perfect itself unless the blossom of the male with its dust is shaken over it, whence it might, in his opinion, almost be concluded that the female plant is not by itself sufficient for the perfecting of the fœtus. He also says in the *De Causis*, that terebinths are some male and some female, and that the reason the first are held to be male is that they are barren. But Theophrastus did not properly understand sexuality in plants, for he mentions a *male* and *female Fern*. According to the writers of this period plants were held to be male rather than female on account of their being taller and more vigorous.

Dioscorides, on whose *Materia Medica* the herbalists of the sixteenth century based their work, applied the distinction of male and female to many plants, but without any regard to true analogy or attempt at the discrimination of the functions of the flower. In the case of *Mercurialis* and several other diœcious plants, the really male plant was called the female, and the distinction of male and female was applied to plants with ambisporangiate flowers, on account of their structure, greater degree of fertility, and other marks unconnected with the fructification, much as was the case in the days of Aristotle.

In the time of Pliny the view held was that plants possess sexuality, and Pliny himself said that the pollen dust is the material concerned in fecundation. In the *Nat. Hist.*, lib. 13, c. 4, he writes thus fancifully on the subject: "All trees, or rather in all things which the earth produces, even in herbs,

the most diligent inquirers into Nature, report that there be two sexes, but in none is it more evident than in Palms. It is confirmed that the wild female Palms do not produce fruit without the assistance of the male, and for this purpose the females bend their boughs to him for mutual embrace. He also marries with the other female Palms, by gentle sighings, tender looks, and the dispersion of a powder. This male tree being cut down, the widowed female afterwards becomes sterile. This love in plants has been observed by men, who imitate it by the scattering of flowers and down of the male, or even only by the dispersion of the powder upon the females."

All this early work seems to have been forgotten. Treviranus says of the herbalists of the sixteenth century: "The idea of a male sex in such plants as Abrotanum, Asphodelus, Filix, Polygonum, etc., was founded only on difference of habit, and not on the parts which are essential to it. But it should be noticed that it is the less learned among the older botanists, Fuchs, Mattioli, and Tabernæmontanus, who make use most frequently of this mode of designating plants. The more learned, as Conrad Gesner, De L'Ecluse, and John Bauhin, employ it only in the case of a plant already known." De L'Ecluse, it is true, in describing the plants which he found, often notes the form, colour, and even *number* of the stamens; in *Carica Papaya*, he calls the individual with stamens the male and the one with carpels the female, since he considered them to belong to different sexes, though the same species; but he is satisfied with saying that it is affirmed that the two are so far connected that the female produces no fruit if the male is separated from it by any great distance.

Among the older English writers Parkinson is the only one who says anything on the subject. Writing of the palm in the *Theatre of Plants*, in 1640 he says: "The date is the fruit of this tree; the best sort were also called *regiæ*, because they were fittest for the dyet of Kings. The ancient Writers have set downe many things of dates—that there are male and female, and that they both beare fruite so that they be within the sight one of another, or else they will not beare—but I pray you account this among the rest of their fables."

Ray seems to have been in advance of his contemporaries in this direction. His system takes considerable account of the flower, though he did not make it the basis of his principal subordinate groups. Of his intimate knowledge of the function of the flower we gain a glimpse in the *Sylloge Stirp. extra Brit.* (1694),

in which he says: "The flowers of plants may want their ornamental parts, as the Calyx and Petals, but none are found to want the apices (stamina)."

But there is some reason to doubt whether Ray's views were of his own origination, and whether they were not really the result of his intercourse with Grew, to whom the credit for the first pronouncement on the subject must be assigned. In his *Anatomy* he devotes a long chapter to the consideration of the flower, the parts of which he describes in terms which seem obscure to the botanists of the present day. He speaks of the "Empalement," which seems to be the calyx; the "Foliature," which was the corolla; and the "Attire." On the question of the latter he is far from clear, and it is not easy to identify the parts to which he refers, except where he illustrates his meaning by figures. It has often been said that by the "Attire" he meant the stamens, but it is more probable that he wished the term to indicate everything within the corolla, for he says on page 171 "the attire or posy in the middle of the flower." On the other hand he does not seem to have included in all cases the *ovary*, though he does include the style and stigma.

In another place Grew draws a distinction between the *seminiform* attire and the *florid* attire. By the first he seems to mean the stamens, style, and stigma; he speaks of "a little *Sheaf* of *Seedlike Particles;* standing on so many *Pedicills*, as the Ear doth upon the *End* of the *Straw*." He certainly distinguishes the style in the centre, and describes it, but does not indicate any difference between it and the stamens. By the *florid* attire, he means the florets of a capitulum. "Every *Flower* with the *Florid Attire*, Embosomes, or is, a *Posy* of perfect *Flowers*."

Grew's study of the construction of the flower led him to the suggestion of sexuality. In his well known memoir read before the Royal Society, November 9, 1676, he states that in the course of a discussion of the subject with Sir Thomas Millington, the Savillian professor, the latter told him that he had formed the opinion that "the *Attire* doth serve, as the *Male*, for the *Generation* of the *Seed*." Grew's reply shows that he had already given the subject much thought and had come to a similar conclusion: "I immediately reply'd, That I was of the same Opinion; and gave him some reasons for it, and answered some *Objections*, which might oppose them." Grew gives no further account of the discussion, and Millington left no written record of his views. It seems, therefore, as if the credit of the suggestion, so far as it was a serious

contribution to knowledge, must be ascribed to Grew, whose views were at any rate thought out with care. They were at the same time very far from clear, for he evidently imagined that the mechanisms involved in the process of fecundation must correspond to those of an animal and with a certain ingenuity he sought to demonstrate homologies between the structures of the two organisms, which from the nature of things were extremely forced and unnatural. He was in a difficulty also with regard to the attribution of sex to the attire; he held that while it was young and before it opened it was essentially female, and that after it had opened or cracked it became male, a curious conclusion which he based upon the same misreading of the structures.

Grew missed entirely the function of the pollen. He knew that it "falls down upon the Seed-case or Womb," but his interpretation was that in so doing it "touches it with a Prolifick Virtue." In short the pollen is fecundating not by admission of the farina into the seed vessel, but by means of "subtle and vivific effluvia," an opinion adopted afterwards by Linnæus.

Grew was certainly familiar with the general characters of pollen through having examined that of many species. In his earlier paper on the flower, published in 1671, he speculated as to its function in a way that shows that at that date the idea that it is concerned with reproduction had not occurred to him. It is strange that he described the visits of insects to flowers and spoke of their carrying away honey, wax, or "particular parts of the Attire." His interpretation of such visits was made entirely from the side of the insects, that their visits were of any importance to the flower escaped his notice.

Indeed in this section of physiology, as on the more general problems, Grew showed a remarkable lack of grip. His anatomical work was very fine, but his deductions from it as to physiology and his physiological speculations in themselves were in the main worthless. It is clear that his views were based on conjecture and not on experiment. In his great work he has left no record of any effort of his own to establish his theory by the experimental method.

As we have seen, Ray was a supporter of the theory. In the *Historia* of 1686 he "threw some light on the very obscure train of thought in Grew's mind, and did something to put it on the right track by referring to the case of diœcious plants and to the old experience of the date palm."[1] His pronouncement here

[1] Sachs, *History of Botany* (English trans.), p. 384.

was not very emphatic; it was given with much less reserve in the *Synopsis* of 1690, and was fully endorsed in the *Sylloge* in 1694, so that his views seem to have developed or matured on reflection.

We may quote at length from the *Historia* the following passage: "Our countryman Grew supposes the stamina to perform the office of the male, and that the pollen or little globules with which their apices are filled, and which separates from them when mature, serves the purpose of fructifying the parts which must be fecundated, and that the majority of plants are bisexual, that is contain both sexes in the same corolla. Not that plants, like the snail and some other species of animals, are androgynous, but are sufficient of themselves to produce their kind. Nor is there occasion that the farina should pass into the uterus (ovary) or the seeds, but only a subtile effluvia which is capable by itself of vivifying the included embryos. . . . Besides bisexual flowers there are others strictly unisexual, having the two sexes apart, for from the same sort of seed there shall spring up two plants, whereof one shall bear only stamens or males, and the other only pistils or females. Of this kind are the date-bearing palms, according to Pliny, the large cedar, and from our own observation many of the willows; and in herbs, the hop, hemp, mercury, nettle, spinach, and a great many others. . . . This opinion of Grew, however, of the use of the pollen before-mentioned wants yet more decided proofs; we can only admit the doctrine as extremely probable." In another passage Ray was a little more emphatic. "Plants comprehended in this section, if they do not differ in sexes, *a doctrine which we maintain*, nevertheless possess at least the shade or similitude of sexes, since in the same species of plants some are found barren, producing no seed; while others are fertile producing seed. The latter some have called males, the former females; others, of which number we are, more justly make the barren males and the seed-bearing females."

In the *Synopsis* Ray says: "Hence it may be collected that the stamina are not an idle and superfluous part, but on the contrary very useful and necessary. Hence indeed is confirmed the opinion of those who teach that the dust contained in the apices of the stamens performs the functions of the male."

While we may claim thus for English botanists, the idea of sexuality as pertaining to plants, we must admit that they did little or nothing to establish it on an experimental basis. This was accomplished in the course of the next decade by Camerarius at Tübingen in Germany, who devoted several years to an eluci

dation of the problem. His first paper, which was mainly tentative, was published in 1691, but the full account of his experiments did not appear till 1694.

It is noticed by Blair in the *Botanic Essays*, which were published in 1720, that some experiments were made on the question a few years after the work of Camerarius appeared. Information was given to him by Dr. Sherard that in the year 1700 Bobart the younger, then *Præfectus* of the botanical garden at Oxford, sowed some seeds of *Lychnis sylvestris simplex* (now known as *L. dioica*) which he had taken from a plant whose flowers bore stamens without apices (anthers), but no plants sprung up. The statement that he had published this fact was drawn from Blair by a communication from Professor John Martyn to the effect that he had made some experiments on this same species of *Lychnis* and had failed to find the seeds capable of germinating. He referred his friend to the *Essays* in a letter dated February 24, 1724.

It is the fashion of to-day, following the dictum of Sachs, to give Camerarius the whole credit of the discovery of sexuality in plants, and to pass lightly over the speculations of the English writers as practically worthless. This seems hardly fair. It is true that Camerarius took up their theory and found on experimental inquiry that it was in consonance with fact. But surely the enunciators of a theory so far-reaching and of such fundamental importance are entitled to share the credit with later workers, who presumably built upon their foundation. Grew's suggestions were made several years before Camerarius entered the field of inquiry, and it may be claimed with complete consistency that the hypothesis of sexuality may be ascribed to them jointly, the one furnishing the idea, the other the detailed investigation, for Camerarius seems to have been led to his experimental work by a consideration of the arguments of Ray and Grew.

Another botanist may be recalled here, who put forward a theory of the process of fertilisation during the lifetime of Ray. This was Samuel Morland, who contributed a paper to the *Philosophical Transactions* in 1703. After quoting Grew's theories he advanced some views of his own to replace Grew's suggestion of the mystic "effluvia." He held "That the seeds which come up in their proper involucre are at first like unfertilised ova of Animals; that the Farina (Pollen) is a Congeries of Seminal Plants, one of which must be conveyed into every Ovum before it can become prolific. That the Stylus in Mr. Ray's language, the upper part

of the Pistillum in Mr. Tournefort's, is a Tube designed to convey these Seminal Plants into their Nest in the Ova." A little investigation would have convinced him of the untenability of his last proposition and have shown him the impossibility of the style conveying to the ovary solid bodies like pollen-grains. His ultimate hypothesis of the deposition of a seminal plant in the ovule seems an anticipation of the well-known theory of Schleiden, promulgated so many years later.

Morland's position was fairly advanced for the time. He accepted the doctrine of sexuality as proved, and set himself to study how the pollen is of service in causing the development of an embryo. But he was a bad observer. He thought that the pollen in the Crown Imperial, *Fritillaria imperialis*, a drooping flower, is *washed* through the agency of wind and rain from the stigma through the style into the ovary. In support of his theory of the formation of the embryo he says: "The Seminal plant always lyes in that Part of the Seed which is nearest to the Insertion of this Stylus, or some propagation of it into the Seed-Vessel; I have discovered in Beans and Peas and Phaseoli, just under one end of that we call the Eye, a manifest Perforation (discernible by the grosser sort of Magnifying Glasses) which leads directly to the Seminal Plant, and at which I suppose the Seminal Plant did enter; I am apt to think that the Beans or Peas which don't thrive will be found destitute of it." He does not appear to have noticed this "perforation" in unfertilised ovules, nor to have identified it with the "foramen" observed by Grew.

If we review the progress of botanical science during the latter half of the seventeenth century it presents us with at least two figures of towering importance, each a giant in his own way. Each was the embodiment of a wave of advance, the one in systematic, the other in structural botany. But in both cases, alas, the single wave spent itself and was not followed by another. The names of Ray and Grew stand out alone; Ray had no successor, Grew's only follower was Hales. The two stately figures had much in common. Ardent in the pursuit of knowledge, they were free from the arrogance and self-seeking which their attainments might almost have justified. Both were men of the highest type of character, of the broadest sympathies, and of wide knowledge. We have considered in some detail the evidence which Ray left behind him of culture and piety. Grew, like Ray, was a

prolific writer on other than scientific subjects, though he was most at home with botanical problems. His last published work was theological, "Cosmologia sacra, or a discourse of the Universe as it is the Creature and Kingdom of God, 1701." In a funeral sermon, preached on him by John Shower, the preacher tells us: "He was acquainted with the theories of the Heavenly Bodies, skilled in Mechanicks and Mathematicks, the Proportions of Lines and Numbers, and the Composition and Mixture of Bodies, particularly of the Human Body. Was well acquainted with the whole Body of divinity, and had studied Hebrew to more proficiency than most Divines, so as to read the Scriptures in the Original." His biographer tells us he was "Grave and serious, though affable, just, unselfish, and very charitable to the poor."

It is a pity that Sachs in his well-known *History of Botany* does something short of justice to Grew. He accuses him of "adopting Malpighi's views" in all essential points, but without doing much to advance them by his lengthy discussions on particular questions. A little investigation of the dates of publication of their respective memoirs shows us the injustice of this charge, a charge which never occurred to Malpighi, but which Sachs was the first to make. He belittles Grew's knowledge of chemistry, such as chemistry was at the time, saying "he made some attempt to extend the knowledge of the chemistry of the subject; but his notions were entirely borrowed from the corpuscular theory of Descartes, and he may be said to have constructed his own chemical processes; the consequence was that he usually overlooked the points that were of fundamental importance, and brought nothing to light that could assist the further development of the theory of nutrition."

This criticism could have been passed upon all the physiologists of the age, who, however, for the most part, ignored chemistry altogether. Grew may fairly claim credit for recognising that the problems of nutrition must be based on chemistry.

We have already noticed and commented on Sachs's attitude to the relative positions of Grew and Camerarius with regard to the doctrine of sexuality in plants. The originator of the idea in other cases receives due credit though it may have been worked out by other hands. So we may claim with Pulteney that the honour of the discovery "that the sexual process was universal in the vegetable kingdom, and that the dust of the antheræ was endowed with an impregnating power" is due in the first place to an English botanist.

BOOK III

PROGRESS FROM THE DEATH OF RAY TO THE ADOPTION OF THE LINNEAN SYSTEM

BOOK III

CHAPTER XVII

THE APOTHECARIES' COMPANY AND CHELSEA PHYSIC GARDEN

After the deaths of Ray and Grew a period of comparative inactivity set in so far as England was concerned. Botanical work on the lines already laid down went on, but without much energy.

It was not, however, an age without any progress, for research on the question of sexuality took more and more an experimental form, while systematic study was greatly developed under the influence of the universities of Oxford and Cambridge. Physiology, too, showed some considerable advance under the able leadership of Hales. The appearance of Linnæus on the scene, and the enthusiasm excited by his teaching, gave a further impetus to study, which culminated in the adoption of his artificial system of classification under the advocacy of Martyn and Hope in 1760.

Another factor of considerable importance was the Apothcaries' Company, who, though partly from a technical standpoint, did a very great deal for the development of botanical knowledge in England. Their material interests were of course intimately bound up with the pursuit of inquiry into the medicinal properties or virtues of plants or simples. At a period even earlier than the one now under consideration they had taken active steps to excite interest in botanical study among the younger of their members or adherents. To them, at the end of the seventeenth century, we owe the foundation of the Chelsea Physic Garden, which was for so long a most important centre of botanical activity, both for purposes of teaching and research. Not that the members of the company confined themselves to the medical side of the subject; with larger purpose, and with appreciation of the need of botanical study and exploration, they applied themselves, in the face of great difficulty, to the encouragement of botanical science in its widest sense, and particularly to the cultivation and study of the various exotic plants which, from time to time, were sent

home by travellers. Nor were they content with this form of enterprise; while they founded the garden for purposes of teaching and experiment, and appointed and maintained various officers for such purposes, they prosecuted the exploration of the country for plants, and endeavoured by organised excursions at frequent and regular intervals to disseminate a knowledge of its flora. No doubt they were actuated partly by professional reasons, as they could not fail to see how important the study of botany in general was to an adequate extension of knowledge of the sources of the medicines on which their craft depended.

Though the foundation of the Chelsea garden took place in the last quarter of the seventeenth century, it could hardly be said to be satisfactorily established till the beginning of the eighteenth, when it exercised its greatest influence on scientific research.

The use of the botanic garden as an instrument in such studies was no new thing, for, as we have already seen, the older herbalists relied very greatly upon it. The first botanic garden of which we have note was Lord Zouch's garden at Hackney, which was under the care of L'Obel. The second was Gerard's, the third Tradescant's, but these were probably more private than public. They were, at any rate, private property, as were, at a later date, many smaller gardens in which a certain amount of cultivation of rare plants had been pursued. The association of a botanic garden with a university chair had been made some years earlier at Oxford, to the temporary advancement of the study there under Morison and Bobart. The garden at Chelsea, however, was different from all these in its standing and in its conception. It was founded by a public body at the outset for specific educational purposes.

It should be noted, however, that Evelyn speaks of a physic garden at Westminster in the middle of the seventeenth century. This seems to have been the property of the Apothecaries' Company also, for an arrangement was made in 1676 for transferring its plants to Chelsea.

The first entry in the minutes of the Apothecaries' Company which deals with the subject of the Chelsea garden dates back to 1673, when negotiations are spoken of with a Mr. Gape, who promised to wall it in within five years at his own cost. There was, however, almost immediately some dispute on certain points of law about the ground, and legal proceedings in Chancery ensued. In 1674 the Company's minutes say that they rented Mr. Gape's garden at Chelsea and the plants therein for a year and a quarter, at a rental of £16.

A different account of its foundation is given by Field, who says that it was acquired on lease for sixty-one years from 1673 from Mr. Cheyne, and that it was at once walled in and laid out as a garden during 1674, the expenses being met by private subscription. It appears to have been planned on the lines of Ray's system, an arrangement which lasted till the Linnean system came into vogue nearly 100 years later.

The early development and maintenance of the garden were beset with many difficulties, especially of administration. The first gardener was appointed in 1677, but great slackness prevailed under him, and the minutes of the Company indicate that they believed themselves to be wronged and cheated by the staff. We find that the gardener's wages were fixed at £30 per annum, with a house.

The story of the early years is full of discouragement; the gardeners were incompetent or dishonest; the plants supposed to be under cultivation fell considerably short of the gardeners' lists, and specimens were continually being stolen. Despite these annoyances, however, the Company persevered; greenhouses were built, and a laboratory supplied. In 1681 it was determined to provide a library also for the use of the laboratory and garden.

The garden so established attracted public attention, and was mentioned in 1685 by Evelyn.

The next few years present a constant scene of strife, the gardener quarrelling with the Company, and the Company complaining of the expense which his management put them to. The gardener, one Watts, complained that the Company's payments were in arrears, and asked for more regularity in discharging the necessary accounts. The Company retorted that too many men were employed at the garden during the dead season, and that if he persisted in having so large a staff entirely for his own benefit, they ought not to be called upon to pay them. It seems that they expected a certain stock of physic plants or simples to be kept under cultivation, and anything the gardener could raise in excess of such requirements he was at liberty to dispose of for his own advantage. More disputes of the same kind arose in 1683, which, however, they settled for the time being by agreeing to allow the gardener a salary of £100 per annum for seven years. Watts, however, disappeared altogether in 1689.

Doody

Naturally this condition of strife prevented progress; indeed a collapse of the whole scheme seemed imminent. Matters dragged on with varying degrees of difficulty till 1693, when an end was brought to the confusion by a total rearrangement of the manner of conducting the enterprise. The garden was put under the care and management of Doody, the friend of Ray, who has already been alluded to. Bobart the younger, then *Præfectus Horti* at Oxford, was an unsuccessful candidate for the curatorship. Doody was practically the saviour of the garden, being indeed the first man of any note connected with it. His personal standing as an apothecary in London was attested by A. L. de Jussieu, who spoke of him as "inter Pharmacopæos Londinenses sui temporis Coryphœus." Doody was not merely an apothecary but a botanist of some distinction, interesting himself chiefly in the comparatively unknown Cryptogams. Doody not only assumed charge of the garden, but made himself responsible for securing the necessary funds for its maintenance and development. His own salary as curator was fixed at only £100 per annum. The arrangement lasted only two years, a further readjustment being made in 1695, when the garden was formally leased to him, in conjunction with Petiver and two other members of the Company, for twenty-one years. It remained under Doody's superintendence till 1706, when he died.

During the latter part of Doody's control negotiations were set on foot between the Company and Lord Cheyne for the purchase of the freehold, but the parties could not agree upon the terms. In 1697 the rent was increased to £75, but how or why is not stated.

Petiver

At Doody's death in 1706, Petiver was appointed to succeed him with the title of Demonstrator of Plants. Like his predecessor, he was a practising apothecary, being attached to St. Bartholomew's Hospital and later to the Charterhouse. We have seen that he, too, was an intimate friend of Ray, and assisted him in the preparation of the last volume of the *Historia*. Petiver was something more than an amateur in natural history pursuits. In addition to publishing, in 1702, a work of great value, under the title of *Gazophylacii Naturæ et Artis, Decades decem*, illustrated by 100 plates, he accumulated a collection of natural history

objects for which Sir Hans Sloane offered him £4000, an offer which, however, he declined. It came into Sloane's hands after Petiver's death, and is now in the British Museum.

During the latter part of Doody's life increasing age and ill-health had rendered him unequal to the demands made upon him by the charge of the garden, and it had gradually deteriorated, so that at his death it was found to be in a rather sorry condition. The Company again contemplated giving it up, but ultimately they put it into the hands of a body of ninety trustees, who agreed to keep it up at their own expense, as a botanic garden, and to pay the Company £5 per annum. They did not, however, find it easy or satisfactory, and little progress was made under Petiver.

Sloane

At this crisis another figure appeared on the scene who played a most prominent part in the ultimate establishment of the garden, and to whose influence it owed, in great measure, its later prosperity. This was Sir Hans Sloane, with whose name, perhaps, as much as with the Society of Apothecaries, the garden is associated.

Sloane was of Scotch ancestry, but was born at Killileagh in Ireland in 1660. In his youth he studied medicine in London, but being a person of considerable fortune, and hence able to travel as he wished, he soon went abroad to study chemistry under Stahl. He became acquainted with Ray in 1679, and studied botany under his influence at Chelsea. After a short stay in England he again visited the Continent, travelling with Tancred Robinson, Ray's friend, and for a time he was a pupil of Tournefort at Paris. This early chapter of his life came to a close in 1684, when he took up his residence in London and remained there three years. The fame of his scientific attainments secured his election as a Fellow of the Royal Society in 1684.

His stay in London was brought to an end by his being appointed physician to the Duke of Albemarle, who was just then appointed Governor of Jamaica. The opportunity to do new scientific work in a totally fresh field offered great attractions to Sloane, and he embraced the Duke's offer with avidity. It was a splendid opening to a man of his tastes, for the West Indies were botanically quite unknown. Sloane was there for only fifteen months, owing to the unexpected death of the Duke soon after his arrival, but during this time he accumulated much material

and laid the foundation of a knowledge of the very interesting flora of the island. He brought back with him specimens of 800 species of plants.

On his return he again settled in London, where fresh honours fell to his share. He was made Secretary of the Royal Society in 1693, and held the office till 1712. It is noteworthy that during his tenure of this post he revived the publication of the *Philosophical Transactions*, which had been suspended since 1687. In 1694 he was made Physician to Christ's Hospital, an appointment he held for thirty years. In 1695 he married. In 1696 he published a Prodromus of his Jamaica plants, under the title of "Catalogus Plantarum, quæ in Insula Jamaica sponte proveniunt, vel vulgo coluntur; cum earundem Synonymis et Locis natalibus; adjectis aliis quibusdum quæ in Insulis Madereæ, Barbados, Nieves et Sancti Christophori nascuntur; seu Prodromi Historiæ Naturalis Jamaicæ Pars Prima. 8vo, 1696. Præter Indicem valde copiosum Nominum et Synonymorum." He arranged the plants on the lines of Ray's system, but showed some carelessness in referring them to genera. He showed, however, the minutest care to determine the species accurately so far as they could be identified with those previously described, so as to avoid any unnecessary multiplication of species; consequently his list of synonyms was very full. The whole of the plants were afterwards incorporated in Ray's third volume of the *Historia* in 1704, Sloane having put his manuscript at Ray's disposal.

Sloane was a great collector of natural history specimens from his early days; by the time he returned from Jamaica he had amassed a very considerable number. In 1702 the collection was greatly increased by the addition of a similar accumulation made by a Mr. Courten, and he continued to add to it during his life. In 1724 it contained 200 volumes of pressed plants, together with 26,000 other specimens. Before his death the number had risen to upwards of 30,000. He accumulated also a library of 50,000 volumes, which included a very large and valuable collection of manuscripts.

In addition to the Prodromus, Sloane published an account of his travels in the West Indies in two folio volumes, which were partly historical and partly descriptive. The botanical results were dealt with mainly in the first volume, which appeared several years before the second. He submitted the whole work to Ray, and received his approval before publication. Later he contributed many memoirs to the *Philosophical Transactions*.

Further distinctions awaited Sloane after the publication of the *Catalogus*. He was made a Doctor of Physic of Oxford in 1701, a foreign member of the Royal Academy of Science of Paris in 1708, while, after a short tenure of the Vice-Presidency, he succeeded Sir Isaac Newton as President of the Royal Society in 1712. In 1716, after the accession of George I., he was made a baronet and appointed Physician-General to the army. In 1719 he was chosen President of the Royal College of Physicians, a post he held for sixteen years. George II. appointed him to be his Physician in 1727. He gave up the Presidency of the Royal Society in 1740, and retired to Chelsea, where he died in 1752.

But it is in connection with the Chelsea garden that his work appeals to us here. In 1712 he purchased the Manor from Lord Cheyne, but the negotiations for its transfer were protracted for several years before they were ultimately crowned with success and the freehold transferred to the Society of Apothecaries. In the Society's minutes under date June 26, 1718, it is recorded that "The Master announced that he attended Sir Hans Sloane, who testified himself very willing to settle the garden on the Company according to his former intention, and he referred them to his Counsel, Mr. Webb, and requested that a meeting should take place between Mr. Meres, the Clerk, and Mr. Webb at the Grecian Coffee House." The minutes for the next year (1719) state that the deeds of conveyance of the garden from Sir Hans Sloane were reported as ready for sealing on February 8. The company agreed to bear the expenses of keeping it up, and they set apart for its maintenance certain fines amounting to £112, 10*s*. per annum. For some reason the conveyance seems not to have been finally executed till 1722.

Among the conditions which Sloane made was one that the Company should send fifty plants from the garden to the Royal Society every year. Failure to observe the stipulations of the conveyance was to involve the reversion of the lease to the Royal Society. The first donation of the plants is noticed in the Company's minutes on March 14, 1719, when the fifty specimens were reported ready, and "a letter referring to them was prepared for forwarding therewith."

Rand

The resuscitation of the garden was thus brought about through Sloane's instrumentality. Under private management it had been starved for years, but funds were at last forthcoming, and

the working established on a satisfactory basis. The re-organisation was made the occasion for a change of the staff. The old gardener, Charles Gardiner, was, according to the minutes of the Company for 1719, paid a quarter's salary and discharged, and a new gardener named Miller was chosen. It is probable that this was the father of the Philip Miller who was for so long associated with the garden, as Pulteney says the latter was appointed in 1722 and succeeded his father. It is a little unfortunate that the minutes are not a little more explicit.

A new office was established, the Director of the Garden, the new title being made supplementary to that of the Demonstrator of Plants, held by Doody and Petiver in succession. Petiver had died in 1718 during the negotiations, and the office was allowed to remain vacant till 1724 when Isaac Rand was appointed to the chief place.

It may be noted that two years afterwards, under the management of Rand and Philip Miller, the accounts of the Apothecaries' Company showed a profit of £45 on the garden.

Rand was a man of considerable reputation as a botanist and moved among the foremost of the time. He did not, however, do much to advance botanical progress, publishing only one or two catalogues of the plants growing in the garden.

Philip Miller

Miller left a much more important mark upon science. He was, however, primarily gardener rather than botanist. In this capacity Pulteney says: "He raised himself by his merit from a state of obscurity to a degree of eminence but rarely if ever before equalled in the character of a gardener." Born in 1691 he was appointed gardener through the influence of Sloane, and he held the post forty-eight years. He was really the first of the Chelsea staff to show any enterprise in the stocking of the garden. He opened up correspondence with lovers of nature in Africa, Siberia, the continent of North America, and the West Indies, and from all those regions he procured continual supplies of rare and new species which he kept under cultivation.

Besides managing the garden Miller distinguished himself by the production of the *Gardener's Dictionary*, the greatest work of the period. The work made a great sensation both at home and abroad; published first in two 8vo volumes in 1724, it appeared in one volume folio in 1731, and passed through many

editions, besides being translated into Dutch in 1746, German in 1750, and subsequently into French. With the resources of the garden at his disposal he was able to supplement it by his *Figures of Plants* which he began to publish serially in 1755. There were 300 tables of these, in two folio volumes, which illustrated the most beautiful, useful, and uncommon of the Chelsea plants. Each number was accompanied by several pages of letterpress containing the appropriate descriptions.

In the early editions of the *Dictionary*, Miller adopted the system of Tournefort, but in the seventh, which appeared in 1759, he exchanged it in great measure for that of Linnæus, which was then assuming its dominant position. He made very great improvements in the successive editions, and he states that the number of plants cultivated at the time of publication of the 1768 edition was more than double those known in 1731. He at first was somewhat reluctant to adopt Linnæus' system, but he made use of its nomenclature entirely in 1768.

This work was in truth monumental; it laid the foundation of all the horticultural taste and knowledge in Europe.

Miller wrote many smaller works, of which the chief was the *Gardener's Kalendar*, a treatise of much practical value to the members of his craft, as it contained directions for every month's work in the garden, setting out in order for them the operations of the year. Appearing in 1731 or 1732, this work also passed through several editions.

There can be no doubt that Miller was by far the greatest gardener of his time, if indeed he may not be considered the greatest that had appeared in England. But he was well known in other spheres more scientific than practical. We shall have occasion later to refer to some of his investigations into the question of the sexuality of plants, which were not without their importance in the history of that subject. We must also regard him as one of those responsible for the introduction of the Linnean system into England, though how far this marked him as a man of science may be open to some discussion.

Elizabeth Blackwell

Chelsea, under Rand and Miller, was something more than a mere ground for the work of the elementary medical student. It was a centre of botanical enterprise and the scene of such development of the science as England showed at the time. The gardens

became of great service to the workers who had little opportunity for local or general exploration. Among these may be mentioned Mrs. Elizabeth Blackwell, a friend of Sir Hans Sloane, who was singularly gifted as an artist, and who took up the task of preparing a herbal of medicinal plants that should appeal to its readers, not only by its letterpress but also by its illustrations. She showed her preliminary paintings of flowers to Sloane and to another friend, a Dr. Mead, and they, being much impressed by their artistic merit, advised her to take up her residence near the garden, in order that she might have fresh authentic specimens continually before her. Both Rand and Miller gave her every assistance, and enabled her to prepare a very satisfactory collection of floral illustrations, which after completion she engraved in copper and coloured the impressions by hand. The first volume of the *Herbal* was published in 1737, with a recommendation from Rand, Sherard, Mead, and others, and carried by way of preface a testimonial from the College of Physicians. The preparation of a second volume occupied her for two years, and the whole work was then issued under the following title: "A Curious Herbal, containing 500 Cuts of the most useful Plants which are now used in the practice of Physic; engraved on folio copper-plates after drawings taken from the life. By Elizabeth Blackwell. To which is added a short description of the Plants and their common uses in Physic. 1739." The engraved page accompanying each plate was the work of her husband, a son of one of the Principals of Marischal College, Aberdeen. He was a doctor by profession and author of a treatise on agriculture. Later in life he took up his residence in Sweden, and in consequence of some ill-judged interference in politics there, was condemned to death and executed. In these descriptive pages the Latin and the English officinal name of each plant was followed by a short description, and a summary of its uses and qualities. This work of Mrs. Blackwell suggested the subsequent work of Trew in Germany, in which her plates were copied and supplemented by drawings of additional plants, including many newly introduced into medical practice.

But another and far greater name must be associated with the career of Miller. It was under his tuition that Joseph Banks began the botanical researches which have made him remarkable among English men of science. His mother lived at Chelsea, close, indeed, to the garden, and here he received his early bias towards botany. This is not the place nor the connection to discuss his work nor the influence which he exerted over so widespread

an area—this must be reserved for a later section. But it was to Miller's influence and to the attachment he developed to the Chelsea Garden that he owed much of his ultimate distinction. He was a frequent contributor to its treasures, sending to its keepers more than 500 varieties of seeds collected during his voyages. Miller died in 1771, having resigned his post at Chelsea in the previous year.

There is little to add to the history of the garden during the period with which the present chapter is concerned. The Apothecaries' Company commemorated the services of Sloane by erecting a statue of him in the garden, which, executed by Rysbach the sculptor, was set up in 1737 and still occupies a prominent position there. Rand continued to hold the position of Director till his death in 1739. He was followed by a succession of capable men, all of whom were eminently successful in their management of affairs. In 1765 the post was held by William Hudson, a Fellow of the Royal Society, to whom we shall refer later as the compiler of the text-book which ultimately took the place of Ray's *Synopsis* as the leading English flora.

The Herborisings

Though the establishment of the Chelsea Physic Garden was the most important service rendered to botany by the Society of Apothecaries, there was another feature of their interest in the science which claims some detailed notice. They organised for their members and apprentices a regular system of botanical excursions, or, as they were termed, *herborisings*, which, under competent leaders, were continued for more than 200 years. As far back as the time of Johnson, the Apothecaries used to form a Society each year to make excursions round the environs of London to investigate the plants. It is probable that Johnson's two *Itinera*, to which attention has been called, were the outcome of them. They were organised more fully about 1633 and maintained for some time, when for some unknown reason they were discontinued. After the garden was established and a competent staff appointed, they were revived and carried out under definite regulations. They were then quite a feature of the work at Chelsea, and gave an impulse to similar excursions on the Continent organised by Bernard de Jussieu, Haller, and Linnæus.

Originally one was organised per annum, known as the General Herborising, but subsequently the number was increased to six.

The General Herborising was confined to the members of the society, but the other five were attended by the apprentices, under the guidance and leadership of the Demonstrator of Plants.

A sketch of the regulations may be interesting. In the instructions given to Wm. Curtis on his appointment as Demonstrator the duties of his office were set forth at length by the Committee, and from these may be taken the following clauses bearing on this section of his work. " His duty is to encourage and cultivate the knowledge of Botany, as well theoretic as practical, among the Students of this Society, for which purpose . . . He is expected to make some annual excursion, for 2 days at least, preparatory to the Society's General Herborising, inviting two or three of the ablest botanical members to his assistance, the intention being to collect such vegetables as are not commonly found in the environs of this metropolis, to be demonstrated by him at the meeting appointed for that purpose. . . . He is to accompany and conduct the Students of this Society in their search after indigenous plants, upon every day appointed for their private herborisings which are only five in each summer; when he is desired to use his best endeavours in preserving strict decorum among his pupils and in directing and confining their attention to the intended business of the day. . . . He is to attend each private Court at the Hall during the summer months to give his advice relative to the private herborisings. . . . And . . . it is earnestly recommended to him to cultivate an extensive botanical correspondence both at home and abroad."

Of the five private herborisings, two were held in May, one in June, one in July, and one in August and they were limited to the neighbourhood of London. The General Herborising was on a larger scale; the excursion sometimes extended for 30 to 50 miles and lasted two or more days. The plants collected on this occasion were exhibited to the members and distinguished guests on a fixed day in July, and a discourse was then given on them by the Demonstrator. This annual exhibition was held at some suburban hotel and, marking its essentially English character, the company celebrated the occasion by a dinner.

The five private excursions were arranged somewhat differently. The apprentices assembled at some appointed place at 6 o'clock in the morning and the Demonstrator met them and took charge. There were several routes marked out in the neighbourhood of London and one of them was chosen for each particular occasion. After two hours' walking they breakfasted together, and on

resuming, worked at their exploration till dinner-time. Dinner was taken in company and afterwards they rested and studied their captures for an hour or two. Tea followed, and the company then dispersed, finding their way home as each preferred. During the afternoon their study of the plants embraced their identification, their individual peculiarities of form or structure and their medicinal properties.

At the end of each season a prize was given to the young man who had found and described the greatest number of plants during the excursions. This prize usually took the form of the British flora in most esteem at the time—in the early days Ray's *Synopsis*, and later Hudson's *Flora Anglica*.

Richardson

A famous personality of this period, the friend of Sloane and Petiver at Chelsea, and of Dillenius at Oxford, was Richard Richardson, a wealthy amateur, who was the possessor of probably the finest private garden in England. He was born in 1663, and educated at Oxford, afterwards proceeding to study at Leyden, where the celebrated Boerhaave was one of his intimate companions. During most of his life he was nominally attached to the practice of medicine, but he was able to indulge his botanical tastes, in the pursuit of which he travelled over most of England, Wales, and Scotland. He amassed a splendid collection of the Cryptogams, many of which he cultivated in his garden. He was reported to possess the second hot-house that was constructed in England. He was no mere amateur, however, for Dillenius alluded to him in the preface to his edition of Ray's *Synopsis* as having, with Sherard, contributed conspicuously by his botanical investigations to a great extension of contemporary knowledge of British plants. He mentioned his work on the Cryptogams in the *Historia Muscorum*.

Richardson was made a Fellow of the Royal Society in 1712. He died in 1741.

CHAPTER XVIII

BOTANY AT OXFORD

The Sherardian Chair

The activity of Morison at Oxford left little immediate result. His successor as *præfectus horti*, Bobart the younger, did little more than complete the *Historia* which Morison's untimely death had left unfinished, and from thenceforward for some years the reputation of the University as a centre of botanical teaching declined.

The next two Professors, Sandys and Trowe, did nothing of importance for the advancement of the science. Happily another notable figure appeared upon the scene, to whose influence and energy great developments were due. William Sherard, to whom is due the establishment of the Sherardian chair, was a young man of about twenty-four at the time of Morison's death, and probably gained some stimulation from association with him and familiarity with his work. The association was, however, not a close one, and he probably profited to a greater extent from his relations with Ray, which, beginning at about the time of the death of Morison, continued so long as Ray was alive.

Sherard was born in 1659, and was educated at Merchant Taylors' School, entering at St. John's College, Oxford, in 1677. He became a Fellow of the College in 1683, when he took the degree of Bachelor of Law. Immediately after his graduation he devoted himself to the study of botany, and travelled for some years on the Continent of Europe with various companions. He sent his records to Ray from time to time, and they were published as a supplement to the *Sylloge Stirpium Europæarum*. In the course of these travels Sherard made the acquaintance of Herman, Boerhaave, and Tournefort. Tournefort influenced his life perhaps more than any other botanist, for he suggested to Sherard that he should take in hand and endeavour to complete the continuation of Kaspar Bauhin's *Pinax*. Sherard took Tournefort's advice, and though he never devoted himself exclusively to the task it was never absent from his plans, and had, indeed, a great influence on the course of most of the rest of his life.

Sherard's active explorations lasted till 1697. He travelled not only in Europe, but paid special attention to various parts of England and Wales and the Channel Islands. His researches in Jersey were inserted in the first edition of the *Synopsis* in 1690. The early part of his life seems thus to have run on very similar lines to that of Ray. It came, however, to a close soon after 1702, when he was appointed Consul at Smyrna. In the leisure which he could secure amidst his official duties there, he worked up the botany of Natolia and Greece, and laid the foundations of a large herbarium, which ultimately came to contain 12,000 species. Nor did the great scheme of the *Pinax* fall through, for he made considerable progress with it in spite of the other claims upon his time.

Sherard returned to England apparently in 1716, and soon afterwards was made a D.C.L. of Oxford. On his settling down he took up his residence in London, but he seems to have conceived the idea of reviving the great reputation that had been associated with his University in his earlier years. Circumstances soon gave him the opportunity for which he was looking. In 1721 he took a fresh continental tour, in the course of which he renewed his acquaintance with Boerhaave. At that time a new and distinguished personality had made a great reputation at the University of Giessen, and Sherard conceived the idea of getting his assistance in his own work, and of establishing him at the head of affairs at Oxford. This was Dillenius, who subsequently became the first Sherardian Professor at Oxford, and who played the leading part in the development of botany in England in the eighteenth century. The drawing together of these two men was, indeed, an event of the first importance in English botany, rendering possible much that had begun to seem hopeless, and giving a fresh stimulus to contemporary and subsequent investigators.

On his return to England, accompanied by Dillenius, Sherard continued to work intermittently at the *Pinax*, which he intended to make a collection of the names that had been given to each plant by botanical writers, in accordance with Bauhin's original design. The task was a colossal one, and it is not to be wondered at that neither in his time or during the life of his fellow-worker was it completed. Sherard assisted Dillenius, however, in other ways, to which we shall refer later on.

Sherard's work at Oxford led to very important results. He left by will £3000 to furnish a salary for the Professor of Botany.

The Chair so endowed was to be renamed after him, the Sherardian Chair, and the endowment was subject to the conditions that Dillenius should be the first Professor under the new arrangement, and that the University should contribute £150 per annum to the maintenance of the garden. The University accepted the endowment, and in due time carried out the provisions of the will, Dillenius being made Professor in 1734 on the death of Trowe.

The garden in Sherard's time was crossed by two double hedges, which intersected at a right angle, cutting it into four symmetrical plots. These hedges were of yew, and the paths between them formed a thoroughfare for the public, who by means of one could cross the garden from the High Street to Christ Church Meadow. The square plots were, however, not thrown open. Abutting on the High Street was a large conservatory, afterwards transformed into a residence for the Professor. The Herbarium was for some years housed there, but the building was pulled down towards the end of the century.

Sherard himself died in 1728. His benefaction to the University went beyond the endowment of the Chair; he erected a professor's residence at the entrance to the Botanic Garden, and gave to the Library there his botanical library, his herbarium, and the incomplete *Pinax*, of which the manuscript is still extant.

He was a traveller, explorer, botanist, writer on a small scale, and in his young days bade fair to become an eminent man of science. Unfortunately little personal reputation came to him; he was rather a patron of the science than a worker at it. His chief contribution to the advance of botany in England was the enlisting of the co-operation of Dillenius and the Oxford endowment.

The figure of Dillenius overshadows those of all other botanists in England during the eighteenth century much as did that of Ray in the seventeenth. It would not be exactly accurate to speak of him as Ray's successor, for he made but little contribution to the advance or elucidation of the principles of classification. His work, though important, was on different lines, and did not bear the impress of original thought or keen insight. He was always an adherent of Ray in matters of classification, and declined to accept the artificial system of Linnæus which began to be promulgated while he occupied the Oxford Chair. He was born in 1687 at Darmstadt of German parentage, and was educated at the University of Giessen. He achieved a reputation at a very early date, becoming known as a writer on botanical subjects,

publishing a series of communications to the Academia Curiosorum Germaniæ, in the course of which he showed intimate acquaintance with many of the Cryptogams, a group with which his name throughout his life was chiefly associated. The care with which he studied them was evinced by the fact that even in his early papers he attempted to establish the possession of sexual organs by these plants. Not unnaturally he made mistakes; for instance, he thought that the capsule of the moss was the male flower. But he was certainly the pioneer in this particular direction. He described the "flowers" of *Lichenastrum* (*Jungermannia*), two species of Chara, and several other Thallophyta.

But he established his reputation as a botanist with a wide range of knowledge by the publication in 1719 of a catalogue of plants found growing in the neighbourhood of Giessen, arranged on Ray's system. He took the opportunity of discussing the system and comparing it in some detail with the rival systems of Rivinus and Tournefort, which were those in greater favour on the Continent at the time.

The work brought him much fame as a botanist and as a writer. He had so well explored the little area he had under observation—bounded as it was by a circuit of 1½ miles—that he had discovered 980 species of flowering plants, 200 species of Musci, and 160 of Fungi, many of which were then new to science. In his descriptions he had put forward his views on classification, and had defined several new genera. Among these we meet for the first time the names *Bryum*, *Hypnum*, *Mnium*, *Sphagnum*, amongst others.

The publication of this work seems to have been what attracted Sherard's attention, possibly on account of the prominence given to the Cryptogams, the neglect of which, by preceding writers, had caused him much regret when he was occupied with the flora of the East during his consulship at Smyrna.

Dillenius was consequently approached by the Consul, and agreed to move to England and take up botanical work there. The nature of his agreement with Sherard is not very clear, but at anyrate at first he resided with him in London as his paid employee, being engaged, in the first instance, on the *Pinax*. No doubt the Oxford proposals were laid before him, but no immediate action could be taken. Indeed there is reason to believe that Dillenius was subjected to a certain disappointment in that direction, for we find that after residing several years in England he became doubtful of the success of the Oxford plan, and entertained the idea of settling in Yorkshire.

We find that on his arrival in England in 1721 he took up his residence in Barking Alley, spending his time there and at Sherard's house, with occasional visits to Eltham, where Dr. James Sherard, the Consul's brother, had a noted garden. James Sherard was also a well-known man of the time, junior to his brother by some seven years. He had been trained as a botanist under Watts, the gardener at Chelsea, and was then a practising apothecary in Mark Lane. He was a man of some scientific attainments, being a Fellow of the Royal Society and of the Royal College of Surgeons.

Though the work on which Consul Sherard mainly required the collaboration of Dillenius was the *Pinax*, it was by no means the only task in which he interested himself. Indeed he seemed to make it a labour on which he could fall back in the intervals of other research. On his first settling down in London Dillenius turned his attention to arranging the great collection of plants that Sherard had brought from Smyrna as well as those he had collected from other sources, which together formed, as we have seen, a herbarium of very considerable dimensions.

In the literature of the day, however, there was a conspicuous gap. Ray's *Synopsis*, which was the recognised British flora of the time, had passed through two editions, but the second, dating back to 1696, had practically become out of print, and the time was ripe for its replacement. Whether at the instigation of Sherard, or actuated by his own regard for Ray, this system does not appear, but Dillenius undertook the task of preparing for publication a third edition, a work in which the Consul gave him active personal assistance. The design of the work was due to Dillenius; familiar as he was with Ray's system he was alive to its deficiencies, and set out to modify it in the direction of his own ideas. He did not, however, succeed in making so many alterations as he wished—probably local English opinion was too strong for him. He altered a good many of the genera, establishing several new ones which still persist, and he added, from his own records and the contributions of others, many new species. In the work he had the assistance of Richardson, a Yorkshire botanist and a friend of Sloane, the author of a memoir on subterranean trees or fossil wood found at Youlé, near York, published in the nineteenth volume of the *Philosophical Transactions*, and also of James Sherard, Llhwyd, Rand, Dale, and others. He gave, as one might imagine he would from his early training, special attention to the Cryptogams, the result being the addition of 40 new species of Fungi, many aquatic plants, and about 150 Musci. Something

like 200 flowering plants brought up the total to 2200, some 400 more species than they amounted to under the then incoming Linnean system. The work was completed and published in 1724, and was illustrated by twenty-four plates of rare plants. This was the last edition of the *Synopsis*; though Dillenius projected another, or at any rate an appendix, three years later, the design was never carried out, and the adoption of the Linnean system of classification in 1760 changed entirely the form of the current English text-book.

During these years in London Dillenius became widely known among English botanists, and at once took a leading position. Among his friends was John Martyn, subsequently Professor of Botany at Cambridge. Together they helped to form a society of botanists, which consisted of seventeen members, Dillenius being President and Martyn, Secretary. The society was not very strong, nor did it maintain itself for many years, being broken up in 1726. Dillenius was elected a Fellow of the Royal Society in 1724, and Foreign Secretary in 1727.

The *Synopsis* being completed, Dillenius began work again upon the *Pinax*, but was soon induced to undertake another task, which brought him a great increase of reputation. This was the "Hortus Elthamensis, seu Plantarum rariorum quas in Horti suo Elthami in Cantro coluit Vir ornatissimus et præstantissimus Jacobus Sherard, M.D., Soc. Reg. et Coll. Med. Lon. Soc. Gulielmi, P.M. Frater, Delineationes et Descriptiones, quarum Historia vel plane, non vel imperfecte a Rei herbariæ Scriptoribus tradita fuit."

It was apparently undertaken at the pressing instigation of James Sherard, not perhaps with full cordiality on the part of Dillenius. He began to collect the materials for it soon after the completion of the *Synopsis*, and it occupied him with intermissions, caused by the death of William Sherard and his own subsequent relations to Oxford, till 1732. As its name indicates, it was a catalogue of the plants cultivated in James Sherard's garden at Eltham, 417 in number, mostly exotics or plants newly introduced into England and cultivated experimentally in the garden. There were with these a few rare English and Welsh plants. The arrangement was alphabetical, but the descriptions and illustrations had seldom, if ever, been approached in England. Dillenius drew and etched all the figures with his own hand, producing them in their natural sizes. The synonyms were given and their propriety discussed.

The work was greeted with enthusiasm by the botanical world, Linnæus in particular speaking of it as "opus botanicum quo absolutius mundum non vidit." When we consider that it was at the outset an interruption to work which lay nearer his heart, we cannot but admire the conscientious care he gave to it. It was, indeed, not so much a work whose scope was calculated to appeal to botanists in general as to bring before the world the glories of James Sherard's private garden, and his relations with the garden's owner were not always of the most cordial character. Indeed, the attitude of Sherard towards the author seems from his correspondence to have been particularly ungracious, especially when the circumstances of its production are borne in mind. In a letter to Dr. Richardson, Sherard says: "Dr. Dillenius has now finished his Hortus Elthamensis. . . . You will see that he has not studied either to adorn his book or my garden; his chief care having been to improve and advance the knowledge of Botany." A few years after Dillenius had taken up his residence at Oxford a letter he wrote to Dr. Richardson throws a very unpleasant light upon their relations. In it he says: "James Sherard hath spoiled it (the Pinax). After Wm. Sherard's death he took me off and set me to work in his garden, to make himself known, and promised to do great things; viz. to pay for the plates, paper, etc., but when it came to the performance he did nothing; and not to lose so many years' labour I undertook it at my own expence. All his kindness ended in an offer to lend me money and to take thirty books (which he did to hinder my taking subscriptions). I finished the book without his money; and he instead of thirty took only ten books, for which I had thirty guineas, I gave him besides one more gratis and some time after, another which in some manner he begg'd of me. This is all I ever had from him. Beside the loss of time and labour, I lose by him at least £200; for it is a book of few people's buying, and therefore I do not think it safe to go through the whole impression. . . . If he had let me go on my own way, I should have made a book in quarto or small folio; but he did not like it, and hath made me draw over fifty more plates to make it look bigger and more pompous, and persuaded me to take royal paper, but hath not given one penny towards the buying of it. If the time which hath been spent in composing this work had been employed in the Pinax, I dare say the Pinax was finished; for I had nothing else to do and was free from all avocations for the space of six or seven years. This is the character I can give of our old friend."

Despite this work, considerable progress was made with the *Pinax*. Dillenius says of it in 1727: "We have entered almost all authors, but to put it in order and to write it fair will require some years toil." Sherard died, however, in the following year, and the burden of the work fell thenceforward entirely upon Dillenius, occupying him with, however, many intermissions during the remainder of his life, and being even at its close unfinished.

The death of William Sherard and the acceptance of the conditions of his will by the University of Oxford, brought about great changes in the life of Dillenius. There were certain difficulties in connection with the changes in the conditions of the Professorship, and it was not till the death of Trowe in 1734 that the new Chair was established, and he went into residence in the University. The difficulties appear to have continued for some few years, for in 1737 we find Dillenius writing of law suits with James Sherard's executors, whereby the stipend of the chair might be imperilled. Eventually, however, matters were satisfactorily adjusted, and he entered on the last period of his life, "arrived at that situation which had probably been the main object of his wishes; and which he considered equally as the completion of his hopes, the asylum against future disappointments, and the field of all that gratification for which his taste and pursuits prompted him to wish and qualified him to enjoy." [1]

One of his earliest tasks at Oxford was to put in order the collection of oriental plants, consisting of about 640 species, which had been made by Dr. Shaw, the Barbary traveller, and to make a catalogue of them. In this he had the collaboration of their collector.

An agreeable incident which marked the year 1736 was the visit of Linnæus to Oxford. Up to that time the two had not been personally acquainted. Though at first there was not very complete sympathy between them, an ardent friendship sprung up, which lasted as long as Dillenius lived. He used his best efforts to induce Linnæus to take up his residence with him at Oxford.

But the great achievement of Dillenius' life was the *Historia Muscorum* which he completed in 1741. From his early youth he had been attached to the study of the Cryptogams, and it was very largely with that group that his reputation was first associated. In those early publications at Giessen he gave promise of what the future held in store and laid the foundation of his

[1] Pulteney, *History of Botany*, Vol. ii. p. 170.

future prominence. Certainly the field was attractive; the whole group was ill-defined and not even recognised as a coherent group at all. Tournefort had put forward a kind of classification, which was very vague and unsatisfactory and governed by no exact principles. Plants of distant affinity were grouped together, mosses, lycopodiums, selaginellas all being considered Musci, lichens were associated with mosses, liverworts, and ferns; while the genera into which the true Fungi were divided were inconveniently large and thus not sufficiently well defined. Ray's attempts at classifying these lower forms were similarly incoherent and unsatisfactory; the arrangement of the *Methodus* did not in all points agree with that of the *Synopsis*.

Coming thus to a heterogeneous mass of forms and tentative efforts to reduce them to some sort of system, Dillenius showed a considerable facility in dealing with the confusion. He first set aside the ferns and horsetails, and of the rest formed the two groups, Fungi and Musci. He had not, however, an appreciation of the true nature of the club-mosses. As we have said, Tournefort's genera of the Fungi were too large to be well defined. Dillenius corrected this by careful analytical subdivision, constituting many new genera with great acumen. Indeed, in his grouping may be seen some conception of the limitations of the genera and larger subdivisions which are accepted by fungologists to-day. He treated his other group, Musci, with similar skill; he separated the Algæ from the land plants, took out the lichens as a separate group, divided up the liverworts according to thalloid or foliose habit, and formed several genera of mosses, giving them names which are still in use. Unfortunately, he did not see that the lycopodiums and their relations do not belong to this division at all.

In the years that elapsed before the publication of the third edition of Ray's *Synopsis*, Dillenius had largely increased the range of his acquaintance with the Cryptogams, and perhaps the work he did upon these plants in this book represents him at his best. He threw Ray's arrangement overboard entirely, and substituted his own views, which may be represented by the following scheme:—

i. Fungi.
ii. Plantæ submarinæ, mainly Algæ, but he grouped with them Sponges and Corals, which were still held to be plants.
iii. Musci, including (*a*) a few Algæ, (*b*) Lichenoides (the Lichens), Mosses, Lycopodium, Selaginoides, Lycopodoides, Lichenastrum (foliose Liverworts) and Lichen (thalloid Liverworts).
iv. Herbæ Capillares et affines, comprising the Ferns, Equisetums, and the Characeæ.

When, after settling down to residence in Oxford, he was able to carry out the idea which he had always had before him and try to do for the Cryptogams what so many of his predecessors had essayed for Phanerogams, a period of nearly twenty years had elapsed since the appearance of the *Synopsis*, and botanical investigation had not been idle during the time. The special feature of the interval had been the appearance of Micheli's *Nova Plantarum Genera* in 1729, in which the classification, especially of the liverworts and the Fungi, had been for the time very fully elucidated. Nor was the classification of the groups alone remarkable; Micheli had learned a great deal about the sexual organs and the processes of fertilisation in the mosses in particular, and the propagation of the Fungi by means of spores.

When we consider the new sources of information thus placed at the disposal of Dillenius, it is impossible to avoid a certain feeling of disappointment with the *Historia*. Not that it is not good; but it might have been so much better. It was a work of very great, almost colossal, labour, containing a critical account of all the species then known of the large group collected under the name Musci. It gave the name and etymology of each genus and its diagnostic characters, and tabulated for each a list of species. To each species, 600 in all, the characteristic marks were assigned, with a full description in each case; the places of growth and the different synonyms were also given. Further, he devoted great care and attention to the "uses" of each, whether in medicine or in the arts of common life. Moreover, he illustrated the work very fully with his own drawings from nature. Still, when all is said, it lacks the touch of genius that can be distinguished in Ray's great treatises; it was a compilation, though a very full and accurate one. It showed, too, that Dillenius had not profited by the investigations of the times as to the physiological problems which the Cryptogams presented. What suggestions there were as to the reproductive processes might almost have been made more than twenty years before, when he was a young beginner at Giessen, at any rate his ideas had not been corrected by the work of Micheli.

Dillenius contemplated following this *Historia* with a similar treatise on the Fungi, but he was never able to carry it out.

The *Historia* was published in 1741 by the Sheldon Press, and bore the following title: "Historia Muscorum, in qua circiter sexcentæ Species veteres et novæ, ad sua Genera relatæ, describuntur, et Iconibus genuinis illustrantur; cum Appendice et

Indice Synonymorum. Opera Jo. Jac. Dillenii, M.D. in Universitate Oxoniensi Botanices Professoris Sherardini, 4°, 1741, pp. 552, Tab 85."

This was the last serious work that Dillenius completed. He died suddenly of apoplexy in 1747 at the age of sixty. His herbarium was acquired by the University under his successor, Professor Humphrey Sibthorp.

It is a little difficult to assign to Dillenius his proper position among the botanists of his adopted country. He lacked Ray's genius, but drew, perhaps, nearer to him than any other of his successors. He attempted and to a certain extent carried out for Cryptogams what Ray had done for Phanerogams. Not that he neglected the latter group; many of the genera which he established hold their places in the floras of to-day. In accuracy of description and observation he was not surpassed by Ray himself. Pulteney says of him that he gave to the botanical fame of England an eminence it had not experienced since the time of Ray. Linnæus's appreciation of his worth has already been recorded. It was shown, perhaps, even more fully by his dedication to him of the *Critica Botanica*.

Dillenius was not conspicuous as an original thinker. When we remember that Morison's great work, associated as it was with the Oxford chair, remained confessedly incomplete, having gained but little from the additions of Bobart, it seems strange that he did not feel impelled to take it up and further develop the system of classification of his great predecessor. But he set too great store by authority; in his colossal labour on the *Pinax* we find no effort to remodel it—indeed he seemed satisfied to go on Bauhin's lines and to acquiesce in its general plan. He was very conservative in temperament, as we find in his original attitude towards Linnæus, whom he considered at first likely to confound rather than to advance botany. This conservatism which we can notice in many instances deprived him of much enterprise; though he wished to improve detail he had no grip of principles like Morison and Ray, nor any of their genius. Consequently botany owes but little to him, even his own special work remaining incomplete. He was no generaliser, his power taking almost entirely the direction of compilation and herbarium work.

After his arrival in England he took little part in botanical exploration. We have, however, a record of a tour which he took in company with two friends, a Mr. Brewer and a Mr. Lyttleton Brown, through North Wales and Anglesea in the

summer of 1726, in which they added considerably to the records of Welsh Cryptogams.

In character Dillenius seems to have been a good deal like Ray; modest, temperate, and gentle in demeanour, retiring in disposition, and in later life placid, philosophical, and calm. In his early days he was more aggressive; indeed an early controversy which he had with Rivinus about the principles of classification when he published his Giessen catalogue showed him pugnacious, rather intolerant, and capable of hasty speech. In his later years another contest which he had with Threlkeld in 1727, when the latter attacked him with some bitterness for making new genera and multiplying species, was conducted on the part of Dillenius with dignified reserve.

Dillenius was even less fortunate than Morison in the appointment of his successor. Bobart took up and carried to some sort of completion the work on which Morison had been engaged. Dillenius was followed in the Sherardian chair by Dr. Humphrey Sibthorp, who conducted his duties on the lines laid down by Sandys and Trowe. Enthusiasm died out, and as far as botany was concerned Oxford returned to slumber.

CHAPTER XIX

RISE OF THE CAMBRIDGE SCHOOL

Botany was later in its development at Cambridge than at Oxford. When Turner was "yet a student of Pembroke Hall" he found little assistance there in his favourite studies—materia medica and the botany of the time. "I could learn," he says, "never one Greke neither Latin nor English name, even amongst the physicians, of any herbe or tree; such was the ignorance at that time." Forty years later very little advance had been made. There is preserved in the Lansdowne manuscripts a draft of a letter in Gerard's handwriting which shows that schemes for constructing a botanic garden as a step towards organised study, were taking shape, though for many years they remained schemes on paper only. "As yt hath beene alwaies myne especiall care (neither doubt I but yt is yours also) to procure by all meanes possible ye floorishing estate of your Universitie in religion and liberal sciences—so at this present (to my great comfort) I see yt not inferior herein to any universitie in Europe, or any other part of ye world, were yt not that many famous nurseries (as Padua, Montpellier, that of Vienna, etc.) had prevented, or rather provoked, us by their good example in purchasing of publique gardens and seeking out men of good experience to dresse and keepe the same. Wherby that noble science of physicke is made absolute, as having recovered ye facultie of simpling, a principall and materiall part thereof. Wherefore, not doubting of your readines in imitating or emulating, the best in so laudable actions I thought yt good to moove you herein and to commend this bearer, John Gerard, a servant of mine, unto you; who by reason of his travaile into farre countries, his great practise and long experience, is thoroughly acquainted with the generall and speciall differences, names, properties, and privie marks of thousands of plants and trees. So that if you intend a work of such emolument to yrselves and all young students, I shall be glad to have nominated and furnished you with so expert an Herbarist; and yourselves, I trust, will think well of the motion and the man. Thus desiring God to prosper all your godlie studies and painfull indevors, I

bidde you hartily farewell." This letter is endorsed: "John Gerard, a Bill of his owne drawing for ye L. Ther. (Burleigh) to signe to ye Universitie of Cambridge, for planting of gardens." This proposal to lay out a botanic garden seems to have been made in 1588 by Gerard to Lord Burghley, who was then Chancellor of the University, but it is doubtful whether the suggestion was ever conveyed to that body.

We have seen that at the time of Ray nothing had been done, nor was the influence of Ray more than personal—he received no assistance from either his College or the University.

The scheme for a physic garden was revived in 1695-96, as we find from an entry in the Vice-Chancellor's accounts: "Spent in London about October 20, about the Physick garden, £2 0 0; Laid out towards the Physick garden as appears in the book, £48 2 7." Part of this sum was probably spent in securing the advice and assistance of "Mr. Loudon, the King's Gardener," who visited Cambridge on this business three times in the course of 1696. The ground, the site of which is not recorded, must have been actually laid out, for it is recorded in the university accounts for 1696-97, with a note that the expense was incurred in the previous year, that the sum of five pounds was paid to one Robert Grumbold, "for measuring the intended Physicke Garden."

For some reason the project was again abandoned, and matters remained as they were till 1724. In that year the University was induced to found a Professorship of Botany and to induct into the chair a certain Richard Bradley, who had achieved some reputation both as an experimental worker and as an author of botanical works. It would be better, perhaps, to regard him rather as an authority on gardening and agriculture than on botany in the strictly scientific sense. Little is known of his career prior to the year 1716, when he wrote and began to publish a work on Succulent Plants which excited considerable attention, being cited indeed by Linnæus. It appeared in five decades between the years 1716 and 1727, and contained descriptions of the plants in Latin and English. He also published other works on gardening which were held in much repute for several years.

In 1724 he approached the University authorities with a view to the appointment of a Professor, and Gorham says, "By means of a pretended verbal recommendation from Dr. Sherard to Dr. Bentley and pompous assurances that he would procure the University a public Botanic Garden by his own private purse and personal interest, he was chosen into the office."

His career at Cambridge was quite a failure. He failed to carry out the garden scheme, and took no active part in botanical work or teaching. Gorham goes on to say: "The vanity of his promises was now (1726) seen, and his total ignorance of the learned languages known. . . . He, however, read a course of Lectures on the *Materia Medica* in 1729. In 1731 he was grown so scandalous that it was in agitation to turn him out of his Professorship."

Gorham's judgment of him was not the only adverse one. His successor in the chair, Professor John Martyn, says of him that he procured appointment to his chair in a clandestine and fraudulent manner and then neglected its duties. The university allowed him to retain the nominal distinction of Professor during his life, but they appointed Dr. Martyn to give the lectures.

These criticisms made very near his time seem possibly too censorious. He was a man whose ambitions went far beyond his abilities, and he was not very scrupulous in the way he pressed for advancement. At the same time he had considerable merit, as was shown from the fact that he was a Fellow of the Royal Society and that his writings were of some distinction. Though he was devoted mainly to the applications rather than to the science of botany he treated those applications in a scientific spirit. His industry and talents, Pulteney says, were not mean, though unadorned by learning. Of his experimental work we shall speak in another connection; here it may be said that he made some contributions of value to the new science of vegetable physiology. Both by his researches and his writings he helped to excite a more philosophical view of the position of gardening and agriculture. He died in the latter end of 1732.

Bradley's successor in the chair, John Martyn, like himself, was not a Cambridge man by training. He was born in 1699 in the City of London, and after being educated in a private school was obliged from family circumstances to devote himself to commercial pursuits. His heart, however, was never in them; he was from his early youth devoted to the study of botany, and was in the habit of sacrificing to its pursuit practically all his leisure and much of his sleep. He became acquainted with Sherard as early as 1719 and with Blair, the author of the *Botanic Essays*, to which we shall refer later, and took part in the herborising excursions of the Apothecaries' Society, studying under Rand. Another of his early friends was Wilmer, subsequently Demonstrator of Plants at the Chelsea garden. As a young man he was associated with Dillenius, became indeed on terms of intimacy and co-operated

with him in forming a Society of Botanists of which Dillenius was president and Martyn secretary. This society, which existed for five years, included among its members Miller of Chelsea, Wilmer, and Deering of Nottingham, a Cryptogamic botanist of some reputation who published a local flora of Nottingham some twelve years later.

During his early years in London Martyn devoted himself to the task of collecting the local plants with the view of preparing a catalogue on the lines of Tournefort's *Catalogue of Plants growing about Paris;* a work which he translated into English in 1720. He was indefatigable in his attention to this task of herborising, exploring the environs of London throughout the year, and in 1723 and 1724 taking a wider range and working in the counties of Middlesex, Surrey, Kent, and Essex. Later he went further afield still; he explored a large area of the south-west of England and penetrated into Wales, accumulating in these journeys a herbarium of nearly 1500 specimens. His journeys were all taken on foot.

In 1725 he began to give public lectures in London. These attracted the attention of Dr. Sherard and of Sir Hans Sloane, and coinciding as they did in point of time with the failure of Bradley to exercise the duties of his Chair at Cambridge, these two gentlemen pressed him to deliver a course there. The connection thus begun lasted as long as he lived; after giving lectures at the University for several years, with the sanction of the authorities, and so acting in some sense as a substitute for the Professor, he was elected to the Chair of Botany on the death of Bradley in 1733.

In 1723 he was pressed by several of his friends to become a member of the Royal Society, but with a rare modesty he held himself unworthy of the honour, and accordingly declined to be put forward. 1724 saw an exact repetition of this course of action, and it was not till 1727 that he consented to stand, and was elected to the Fellowship. He became very active on the Committee for the library and museum, so much so that after 1731 he was excused payment of subscriptions. In 1730 he was a candidate for the Secretaryship of the Society, but was not elected.

From 1727 to 1730 he resided at St. Helens and practised medicine. When his Cambridge work became regular he appears to have first formed the idea of residing at the University. In 1730 he decided to do so, and he entered Emmanuel College with a view to obtaining a further qualification as a physician. Family

affairs led him, however, to abandon this intention, and he removed to Chelsea. Even after his election to the Professorship he continued to reside there, only going to Cambridge to deliver his lectures. But the work at Cambridge was difficult, and in 1734 he discontinued his lectures as there was no botanic garden, and he met with no support. Sir J. E. Smith said, "Botany slept from 1734 till 1761, when Walker raised it from a deep slumber. The Professor had neither salary nor student." Martyn practised medicine at Chelsea for more than twenty years, and then in 1752 went to live at Streatham. In 1761 he resigned his Professorship, being succeeded by his son; on that occasion he presented to the University his herbarium, and his collections of botanical specimens, his drawings, and his collection of *Materia Medica*. He returned to Chelsea in 1767, and died there in 1768.

Martyn's contributions to science were not unworthy of his position as a University Professor. As a young man he produced the translation of Tournefort's *Catalogue;* it was not a mere translation, but was remodelled and enlarged with great advantage. Martyn drew not only from the original, but from the editions that had been brought out by Sherard and Boerhaave and of Bernard de Jussieu, and, for the special wants of the English reader, he added the English names and localities of the plants. Moreover, he elaborated Tournefort's account of the Cryptogams, arranging the mosses after the method of Dillenius and the "Mushrooms and Capillary plants" according to a method of his own.

His first original work was a little volume dedicated to Sloane, "Tabulæ Synopticæ Plantarum Officinalium, ad methodum Raianam dispositæ." This appeared in 1726.

In 1727 he prepared for private circulation a new local flora or text-book for the use of his University pupils. He called it a *Methodus Plantarum circa Cantabrigiam nascentium*, and while he based it on Ray's *Catalogus* he materially amended and added to the latter, so that the work became practically the second flora of Cambridgeshire to be published. Ray's book and the two appendices to it had become extremely rare, and Martyn felt the need of a new handbook to the flora when he began to lecture at the University. He added nearly 200 plants to the list, besides correcting the descriptions of the genera, according to the suggestions of Vaillant, Dillenius, and the other systematists who had written since Ray's death.

Though he began his literary work by a translation of Tourne-

fort's *Catalogue*, he was an adherent of Ray in the matter of system. Some years before the appearance of the new flora he formed a plan of extending Ray's classification, and developing in that connection the importance of the embryo, a work to which he gave renewed attention and thought in 1728, as soon as the *Catalogue* was completed.

Though these proposals never saw the light as a definite taxonomic scheme they are worthy of reproduction as the last speculations put forward in England on this subject prior to the obscuration of scientific research in classification by the artifical system of Linnæus. He followed Ray in the main in the distribution of the chief divisions, but he removed the principal defect of his predecessor's plan by abolishing the division between trees and herbs, thereby improving very greatly the general scheme. He fastened upon Ray's introduction of the cotyledons as distinguishing marks for large groups, and sought to extend the principle to those which are subordinate. There is extant a letter[1] from Martyn to Dr. Blair under date December 16, 1723, in which he develops the idea. " I dare not say that I have seen every species of any one tribe, or one species of every tribe; but by what I have seen, I may form a conjecture that the *Leguminosæ* have their seed-leaves firm and carnous, and most of them not rising above ground; whether they may not upon this distinction form two tribes, remains to be inquired. The *Umbelliferæ* are, I believe, all narrow, long, and pointed. The *Stellatæ*, oval and in a manner cordate; which shows how different this tribe is from the last; though they agree in being *Gymnodispermous*. The *Tetrapetalæ Siliquosæ* are broad and cordate, but easily distinguishable from the *Stellatæ*. In short, I doubt not but I shall find the same concordance amongst the *Verticellatæ*, *Asperifoliæ*, and perhaps *Multisiliquæ*. I do not expect to find the *Apetalæ* agree together. It is a class I am not at all fond of. But I should not wonder to find *Lapathum*, *Atriplex*, *Bistorta*, *Persicaria*, *Plantago*, etc., agree very well in their seed-leaves; and if they do, they may be classed together under the name of *Spicatæ*;—no division, unless we make Theophrastus a modern. The *Cucurbitaceæ* may make a good class; and perhaps the *Malvaceæ* too; and should I find the *Gerania* agree with them, I should not wonder. *Lychnis*, *Caryophyllus* and other true caryophyllous flowers may perhaps make up a class under the title of *Coronariæ*; a term used by some old authors; as is also *Campanaciæ*, which may make

[1] Gorham's *Memoir of John Martyn* (1830).

another. As for the *Monopetalæ* and *Pentapetalæ Valculiferæ*, I have an aversion to them, as well as to the *Apetalæ*."

A few weeks later he writes again, "When I first entered upon the scheme of forming a method from the seed-leaves, I thought their form would be sufficient to found distinctions upon; but on reading Cæsalpinus (who gives more light into this doctrine than any of his successors,) I found that he had observed the situation of the point of the radicle in the seed, and had laid great stress upon it in classing of plants. I agree with you in the observation of the *Cichoraceæ* having long, narrow, pointed seed-leaves, as well as the *Umbelliferæ*, but then the situation of the radicle distinguishes them, according to Cæsalpinus. This author puts the *Umbelliferæ* amongst those *quorum cor* (to use his own words) *externis vergit;* and the compound flowers amongst those whose seeds have *cor in inferiore parte.* In this the *Scabiosa*, according to the same author, differs from compound flowers; which makes me more inclinable to subscribe to the opinion of Dr. Dillenius, who separated it from them; because it has really *stamina* and *apices* like the simple flowers, and proper empalements to the little flowers. Cæsalpinus observes the same difference in the *Asperifoliæ* and Verticellatæ."

Martyn's greatest botanical work was the *Historia Plantarum Rariorum*, which occupied him during his leisure from 1728 to 1732. When we consider the assiduity with which he was pursuing his teaching and other work during those years in Cambridge and in London we may be surprised at this achievement. Gorham says of it, "The design of this sumptuous work was to figure such curious plants as had never been figured before, of their natural size and in their proper colours, to give descriptions of them, and to add their culture and use." The paintings were executed by Van Haysam, and the engravings by Kirkall; they were mezzotints, and printed in their proper colours. The work was issued in five decades, in large folio, and was the most elaborate and ornate that had ever been issued in England. It was in contemplation to issue four more decades, but the work was abruptly cut short by the very great expense attending the preparation of the illustrations.

Besides these larger works Martyn contributed many memoirs to the *Philosophical Transactions*, but they were not very important. He projected a publication of his course of lectures on botany but did not persevere beyond the first. This appeared in 1729 at a time when he was contemplating giving lectures at

Oxford in the interval between Sherard's death and the settlement of Dillenius. It did not go beyond an exposition of the technical terms of the science.

Martyn was concerned in the actual publication of the *Philosophical Transactions*, and in writing the first three volumes of the *General Dictionary*, the memoirs of Bellonius, Boccone, and Brunsfels being from his pen. He translated Boerhaave's *Treatise on the Powers of Medicine*, as well as other books and memoirs.

He was an elegant classical scholar; of this he gave evidence in the publication in 1741 of a translation of the *Georgics*, and in 1749 of another of the *Bucolics* of Virgil. In these works he established the fact, for the first time in England, that Virgil possessed a very profound knowledge of plants, and was, indeed, an accomplished botanist. These works were well received, not only in England, but on the Continent, and added very greatly to his reputation. The translation of the *Georgics* contained engravings of *Citrus medica*, *Elæagnus angustifolia*, *Olea Europæa*, *Lilium Martagon*, and other plants. In the notes to these volumes he discussed the identity of the plants of Virgil, and determined their modern names, a work of considerable difficulty, as in the original there is little attention to specific difference or distinction.

It is interesting to note that after the visit of Linnæus to England in 1736, we find Martyn among his correspondents. His friendship with the great Swede is recalled by an extract from the *Flora Laponica*, which appeared in the edition of the *Georgics*. Martyn did not, however, favour the Linnean system of classification, leaning as he did to the views of Dillenius, and remembering his allegiance to Ray.

A third flora of Cambridge and the neighbourhood was published in 1763, which should be mentioned here. Though at that date the artificial system of Linnæus had met with general acceptance, this was arranged according to Ray's *Methodus*. It was called "Fasciculus Plantarum circa Cantabrigiam nascentium quæ post Rajum observatæ fuere," and was the work of Israel Lyons. It contained a list of about 106 plants found between 1727 and 1730 by Martyn, C. Miller, the author, and other botanists. Lyons was not a very prominent figure of the time, but he was the teacher of the famous Sir Joseph Banks, afterwards President of the Royal Society, at whose suggestion he gave lectures at Oxford during the Professorship of Humphrey Sibthorp. He died in 1775.

During Martyn's professorship the garden scheme made little progress. In 1731 he entertained sanguine hopes of success, which, however, were doomed to disappointment. A Mr. Brownell of Willingham entertained the idea of founding a physic garden for the university, and as he was a wealthy man, and an ardent lover of botany, it seemed likely that the scheme would be carried out. But though the matter was taken up by the Vice-Chancellor, Dr. Mawson, then master of St. Bennet's College (now Corpus Christi) and by Dr. Savage, the master of Emmanuel College, the general lack of interest taken by the University in the subject hindered progress. The ground was actually selected, and Mr. Philip Miller, the famous Chelsea gardener, was called in to advise as to the plan and construction of the garden, the matter fell through, and Mr. Brownell's estate was diverted into another channel.

Towards the end of Martyn's Cambridge career, however, the long desired object was attained. The years 1759-62 saw the definite establishment of a botanic garden and its presentation to the University. It was the gift of Dr. Walker, Vice-Master of Trinity College; the donation was completed in 1762, and the circumstances under which it was made were detailed by him in the following terms: "We have generally had Titular Professors of Botany, but nothing worth mentioning left behind them. Dr. Martyn indeed within our memory, laboured much to bring this science into repute; read public Lectures for several years; perambulated the Country with his Scholars, showing them the Cambridgeshire Plants where Mr. Ray had described them to grow, and making many additions to that Catalogue. But this gentleman's private affairs took him from us, much esteemed for his great knowledge of Plants. About fifteen years ago the learned Physician, Dr. Heberden, was so kind as to oblige the university with a Course of Experiments upon such plants as he then found among us, in order to show their use in Medicine. This was entering into the practical and principal part of Botany, to which we had been strangers since the above mentioned Association. But this Doctor's great Abilities in his profession soon after called him from us, much lamenting the want of a Public Garden, furnished with a sufficient variety of Plants for making the like Experiments. These considerations, particularly Dr. Heberden's most useful attempt, put the present Vice-Master of Trinity College upon finding out a proper situation for such a Garden; who with the assistance of his Friend Mr. Miller of Chelsea, called

in for his great experience and judgment in such an affair, after several treaties that failed, at last pitched upon and purchased the Mansion House, in Free Schole Lane (formerly part of an old Monastry) with nearly five Acres of Garden about it, well walled round, quite open to the South, conveniently sheltered by the Town on the other quarters, with an antient water-course through the midst of it."

The garden was laid out and part of the buildings erected before the transfer was completed, for we find in the correspondence of Thomas Martyn, the son of the Professor, a statement in 1760 to the effect that the foundation of the greenhouse was then laid, but the garden was not yet in any order, and in the next year a further statement running in the following words: "It may perhaps be some satisfaction to you that our garden begins to flourish. Shrubs and trees in abundance are already planted. . . . A stove is building and stone is preparing to raise the superstructure of a greenhouse on the foundation which was laid last year."

The garden was thus founded in the period under consideration. It would seem convenient to anticipate a little and continue to describe it and what it eventually became.

On the ground bought by Dr. Walker were erected greenhouses and other necessary buildings, the cost of which was defrayed by public subscription, and a lecture room for the Professor of Botany was set apart in " the great house " till 1784, when it was decided " to erect a building wherein the Professor of Botany and the Jacksonian Professor may deliver public lectures." The building erected in 1787 at the south-east corner of the garden was very simple in its construction, consisting merely of a lecture room, 40 feet long by 28 feet wide, with a private room for the Jacksonian Professor at the north end and another for the Professor of Botany at the south. A broad gravel path led straight across the garden to the centre of a range of greenhouses, built against the north wall. This walk was carried by a wooden bridge over a long narrow pond, crossing the garden from east to west and dividing it into two unequal areas. The part of the garden between the pond and the street contained the herbaceous plants in a series of parallel beds, while less hardy plants were placed in others between the pond and the greenhouses. Dr. Walker placed the management of the garden in the hands of Dr. Thos. Martyn, with the title of Reader. The first Curator was Mr. Charles Miller, a son of Philip Miller, the famous gardener of Chelsea. So established and developed, the garden continued for over fifty years,

when, having become too small and having greatly deteriorated in the quality of the soil and the condition of its surroundings, it was abandoned to the hands of the builder, becoming the site of University museums and laboratories, while a new garden was established on the Trumpington Road, the University having purchased 30 acres there for that purpose in 1831.

The closing years of Martyn's life were uneventful so far as Cambridge was concerned. During this period, however, his son, who succeeded him as Professor of Botany, was being trained to fill his place. But he made no mark on the science during those early years, and, as at Oxford, practically all botanical work was suspended. The influence of Ray was gradually being superseded by the development of the artificial system of Linnæus, which, though opposed in England on its first promulgation, established itself as the dominant system under Martyn the younger, Miller of Chelsea, and other eminent English botanists in about the year 1760. The change, however, was so gradual that it is difficult to speak of a definite date in connection with it.

CHAPTER XX

BOTANY IN SCOTLAND AND IRELAND

We have seen that with the early years of the eighteenth century the development of the science of botany received a somewhat severe check. Sutherland came under the censure of the municipal and university authorities, and was practically dismissed from his second chair in 1705, maintaining, however, his position as King's Botanist, with control of the Holyrood garden, till 1715. The University appointed Dr. Charles Preston to succeed him, the best appointment possibly that could have been made at the time, but one that did not advance the science. He was apparently a man of little originality, and was content to go on along the lines of his predecessor. At the outset he advertised a course of teaching in the town gardens in the summer of 1707, but seems to have had no classes of students. The garden was apparently kept open for such visitors as cared for instruction, and the professor or one of his assistants was in attendance to help them, but the study of the plants was very crude, their names and the medicinal properties attributed to them being all that it comprised.

Charles Preston died in 1711, and was succeeded by another Preston, George, a near relation, but whether son or brother seems a little uncertain. Like his predecessor he appears to have been mainly interested in the materia medica side of botany, a circumstance which is not surprising when it is remembered that they were both medical men. The Town Council gave George Preston a salary of only £10 per annum on his first appointment, but his stipend was raised to £20 later, on condition of his keeping up the garden and building a greenhouse. The garden was badly situated and not properly enclosed, and it causes little surprise to find that under such conditions and a provision for its maintenance so inadequate, it gradually fell into neglect and ruin. In 1724 it had reached such a condition that it was handed over to the new medical school which was just then being founded on the initiative of Alston and Munro.

Preston was said by Blair to be an "indefatigable" botanist. There is no doubt that he possessed an extensive knowledge of

plants and was well known in botanical circles in England, being a correspondent of Sloane and the Chelsea authorities. Soon after his appointment he published a catalogue of the plants in the garden in Latin and English under the title of "Catalogus omnium Plantarum, quas in Seminario Medicinæ dicto transtulit Georgius Prestonus, Bot. Prof. et Hort. Edinburg." It was only a small 12mo volume. Preston seems to have resigned his chair in 1738 though he lived till 1749.

At Sutherland's retirement from the post of King's Botanist in 1715 the split in the teaching staff was emphasised by the maintenance of the post as independent of the University. Dr. Arthur was appointed to succeed him, but his stay was negligible, for in consequence of his being involved in the political troubles of that year he was compelled to flee from Scotland. The post was filled in 1716 by the appointment of a very distinguished botanist and writer, Dr. Charles Alston, the man who was the most formidable opponent to the introduction into Scotland of the Linnean artificial system of classification. Alston was born in 1683, and commenced his education at the University of Glasgow. Family troubles unfortunately interfered with his graduation, and he devoted himself to professional pursuits, ultimately allying himself with medicine. In 1716, as we have seen, his work was recognised by his appointment to succeed Sutherland. Though he had always shown a disposition towards botany, his training so far had not been such as to qualify him for so high a position. He went, as soon as he could conveniently leave the gardens, to Leyden to study under Boerhaave, and he finally graduated there as M.D. His stay lasted till 1719, when he returned to Scotland and completed his medical course at Glasgow. It was consequently not till 1720 that he was able to take up his duties at Holyrood, but thenceforward he conducted botanical teaching in rivalry to Preston, between whom and himself relations were not always of the most cordial character. This unfortunate condition of affairs, a double staff of professorial standing dealing with a single subject, involving a sad waste of resources and an atmosphere of veiled hostility, lasted until the resignation of his chair by Preston in 1739. At this juncture, the Town Council, says Grant, "with all the air of creating a new office, considering that were a Professor of Medicine and Botany elected and installed in the City's College, it would in a great measure contribute to the advancement of learning, etc.," they therefore "appointed him accordingly." Thus was healed the breach, and henceforward till the

present day the two posts of University Professor and King's Botanist have been held by the same person to the great advantage of all concerned.

While at Leyden Alston formed with Dr. Alexander Munro a friendship which later had important consequences. When he returned to Edinburgh, where, in addition to his botanical work, he practised medicine, the intimacy was renewed and the two projected and carried out a revival of medical lectures at the University, modelled on the curriculum of study they had pursued at Leyden. Munro took up the work in anatomy and surgery, Alston in botany and materia medica, and other departments were filled with little delay by the co-operation of Rutherford, Sinclair, and Plummer. This notable revival was practically the first real organisation of the famous medical school of Edinburgh, still among the first of the medical schools of Europe. Holding the chair of botany and materia medica, Alston continued to give two courses of lectures annually for twenty-two years.

Alston's writings comprise an "Index Plantarum, præcipiis Officinalium quæ in Horto Medico Edinburgense Studiosis demonstrantur," published for the use of his pupils in 1740; a work on materia medica twelve years later; and the book by which he is still chiefly known—the *Tirocinium Botanicum Edinburgense*, published in 1753. The last-named work was aimed against the Linnean so-called sexual system of classification, which was then making its way into acceptance among the botanists of all nations. Alston was always a strong opponent of this system, not so much on account of the basis on which it was constructed as of his hostility to the idea of sexuality in plants. The *Tirocinium* lost much of its effect in consequence of its attempting to invalidate all the arguments of Linnæus as to sexuality. Alston had carried out some experiments which seemed to him to prove that fertile seed can be produced without the co-operation of the stamens of the flower and he consequently held that sexuality as then defined was not based upon experiment as well as theory and shut his eyes to the irrefutable evidence that was becoming day by day more abundant. Had he confined his attack to the point that a system of classification should not be based on the artificial features of the numbers of stamens and carpels, he would have commanded at anyrate the adherence of later botanists, among whom the theory of sexuality was no longer challenged. Alston, however, seemed to oppose not the utilisation of the sporophylls for classificatory purposes, but the idea that sexuality underlay

the system. He was very strenuous in his opposition, and so long as he lived the Linnean system made no progress in Scotland.

Alston was a man of great culture and broad views on most things; he was familiar with the scientific writings of the time, and was worthy of the position he held in the botanical world. But he was always first the medical man, and appeared to regard his scientific work as always subordinate to the claims of medicine. He was an eminently successful professor till his death in 1760.

A pupil of Alston's who came to Edinburgh from Aberdeen gave some slight impetus to the study of botany in the latter city on his return. David Skene by name, he was afterwards a friend and correspondent of both Hope and Linnæus. To him we owe the earliest records of the flora of the counties near Aberdeen.

Till the end of this period the study of the subject was not pursued in either college at Aberdeen. In 1752, however, Marischal College instituted a Chair of Civil and Natural History, one Francis Skene, no relation to David, being the first Professor.

The starting point of botanical study at Glasgow appears to have been a resolution passed by the Faculty of Physicians and Surgeons in 1704 that a garden shall be constructed in part of the great yard of the University for improvement of the students in the knowledge of botany. The terms of the resolution seem to indicate that the study of the subject was already in existence, but there are no records of an earlier date respecting it. Co-incidently with this decision the Faculty appointed one John Marshall to take charge of the work. The minute of his appointment runs as follows:—"The Faculty having resolved to prosecute their own act of July 4 anent the improvement of some parts of their great yard for botany, and a physic garden, do now think it necessary to name one who shall have the charge and oversight thereof, and who may instruct the scholars who shall apply to him for the study of botany, and being informed that John Marshall, chirurgeon in Glasgow, is capable of discharging that trust, and being specially recommended by the Dean of Faculties' letter, therefore the Faculty does nominate the said John Marshall to the said employment."

Though not actually appointed Professor there is reason to think that Marshall enjoyed the title. In 1708 Queen Anne granted £210 yearly from the Civil List of Scotland to provide or augment salaries to the Principal and Professors of Glasgow University, and of this sum £30 was allocated to the Professor of Botany. It is probable that the grant was made to Marshall, no

other name being in any way prominent in connection with the subject.

Marshall had a gardener under him, and the duties of teaching devolved upon them both. Probably there were no classes ; they were in attendance in the garden to give information to such students as sought it there. Marshall's salary apart from the Queen Anne grant was only £20 per annum.

It is probable that Marshall continued to teach the subject till his death, which occurred in 1719. After this, botany no longer had a distinct professor, but the subject was combined with that of anatomy. The calendar says that this arrangement was made in 1718, but there is some doubt as to the accuracy of the date. The first professor of the two curiously conjoined subjects was Thomas Brisbane, a remarkable occupant of the chair, for he is reported to have always entertained a strong antipathy to dissection, and it is doubtful if he ever taught anatomy. Not that his teaching of botany did him much credit ; he needed much pressure to take it up at all, and he abandoned it as soon as he could. In those days professorships were often little more than sinecures, and he was no worse than many of his contemporaries. He was professor, however, till 1742. Shortly before his death the physic garden was either extended or altogether removed to part of the great garden. Robert Hamilton succeeded to the chair, and soon afterwards a better state of affairs was brought about. This was not due, however, to the new professor, or only to a very small extent. So low had scientific teaching fallen in the University that it needed but little to take it away entirely. In 1744 a Dr. Cullen settled in Glasgow, and taking advantage of the condition of the medical school in particular, he commenced to teach medicine independently. In 1748 he added botany and materia medica, and in 1749 chemistry, to his subjects. The authorities seemed much disturbed by his success, and holding that co-operation would be preferable to rivalry approached him with a view to his taking up the University work. The neglect of their duties by the staff was becoming an open scandal, and the influence of the Duke of Argyll was sought to mend matters. The result was that in 1750 Cullen was appointed Professor of Medicine in the University. There is no doubt that he was a man of great ability and of indomitable energy—the man called for loudly by the apathy of the time. Hamilton seems to have recognised the advantages which co-operation between them would entail, and we find in the succeeding years that they worked cordially together.

Cullen's lectures were given in Latin, and dealt not only with botany as applied to the healing art, but as a subject for scientific study. He discussed the principles of classification, explaining to his students the system of Tournefort and the proposals of Linnæus, which, as we have seen, had been put forward a few years earlier. It is a little strange, perhaps, that he left alone the classifications advocated by Ray and by Morison respectively, particularly as the latter was a Scotsman by birth and had been trained at Aberdeen and Edinburgh. It seems clear that under Cullen there was a revival of teaching, which came to compare favourably indeed with what had characterised the time of Marshall.

The co-operation between Cullen and Hamilton is seen in a recommendation made by them jointly in 1754 that means should be taken to make the great garden more useful for the study of botany and that a good gardener should be procured. The recommendation, however, did not serve the purpose hoped for, for no immediate change was made.

Cullen was, undoubtedly, a remarkable man. He practically resuscitated the study of medicine, materia medica, botany, and chemistry; he added largely to the number of students, and by attracting the attention of men of science beyond the borders of Scotland, considerably enhanced the reputation of the University. He removed to Edinburgh in 1756, and was made Joint-Professor of Chemistry, succeeding to the Chair after a few years.

His friend Robert Hamilton followed him as Professor of Medicine, leaving the Chair of Anatomy and Botany to be filled by the appointment of Black; the latter only held it a year, for Hamilton died in the next year and Black was his successor. The Chair of Anatomy and Botany fell then to Professor Thomas Hamilton, brother of Robert.

Botany in Ireland

The early records of botanical work in Ireland are even more slender than those of Scotland. A volume on the natural history of the island was published from the pen of Boate in 1652, but though it contains certain chapters dealing with agriculture, there is little in it about botany. The old English records contain very little about the sister isle. Parkinson mentions one Silliard, an apothecary of Dublin. In How's *Phytologia* and in Merrett's

Pinax references are made to a certain Heaton, a divine who lived at Dublin, who was the first discoverer in Ireland of certain plants which both authors included in their works. He seems to have written a manuscript in 1641, from which later on Threlkeld took the Irish names of plants, commending the author for the fulness and accuracy of his descriptions.

William and Thomas Molyneux both wrote on botanical subjects in the *Philosophical Transactions*. Thomas Molyneux was Professor of Physic in the University of Dublin. He seems to have made a study of the indigenous plants of the country, and to have communicated his results to Threlkeld, who incorporated them in his *Synopsis*.

Caleb Threlkeld was the author of the first authentic treatise on Irish plants. He was born in 1676 in Cumberland and was educated in Scotland. He took the degree of M.A. in the University of Glasgow in 1698, and in 1712 he graduated as M.D. at Edinburgh. In the following year he removed to Dublin, where he practised as a physician till his death in 1728. He was a writer on botanical subjects, but his works are little known, with the exception of the treatise alluded to. This was published in 1727 under the name of *Synopsis Stirpium Hibernicarum*. Though its title was somewhat ambitious, it was only concerned with the plants growing in the neighbourhood of Dublin, of which it gives the Latin, English, and Irish names, together with their medicinal properties. It was really rather of the type of a herbal than a flora. Nor was it very exhaustive, for it contains the descriptions of only a little over 500 species. Threlkeld had even to incorporate in it the work of Molyneux to reach this number.

Threlkeld was not very scientific; he knew the history of the plants better than the plants themselves. Nor was he known very well in England, except for a quarrel that he had with Dillenius over questions of nomenclature and of multiplying species. It was unfortunate that on his side the controversy was overbearing and unpleasant, while the Oxford Professor was as usual courteous and gentle. He did not, however, conceal his opinion that Threlkeld's book contained little if anything that was new.

After Threlkeld's work little of value appeared in Ireland till the end of the century. Some local floras of no great value appeared in the *County Histories of Ireland*, by Charles Smith. They included the counties of Down, Waterford, Cork, and Kerry. The latter is mainly noteworthy as showing that the famous

Arbutus of Killarney is not indigenous, but was introduced in the sixth century by the monks of St. Finnian.

During this early period the University of Dublin was far behind its English rivals in regard to botanical study or teaching. In connection with the medical school of Trinity College a Lectureship in Botany was established in 1711 and apparently a physic garden was cultivated near the school. The latter could not have been on a large scale, but it appears to have supplied the school for more than fifty years. The first lecturer was Dr. Nicholson, who had graduated as M.D. at Leyden in 1709. During the year after his appointment he published a work on the garden: "Methodus Plantarum in Horto, Medico Collegii Dublinensis jamjam disponendarum Dublini, 1712." It was a little pamphlet of about forty pages.

CHAPTER XXI

VEGETABLE PHYSIOLOGY IN THE EIGHTEENTH CENTURY

Development of the knowledge of sexuality in plants

Before dealing with the recognition and acceptance of the Linnean system it will be well to examine the progress of physiological inquiry during the whole of the period with which the present chapter is concerned.

The sexuality of plants, as we have noticed, became the subject of inquiry under Grew and Ray, and was experimentally established by the researches of Camerarius a little later. The term used, sexuality, was understood in a very different sense from its present acceptation. It implied nothing more, as applied to flowering plants, than the occurrence of pollen and the necessity of pollination as a preliminary to the formation of the fruit and seed. This was held to be the true sexual act; the full explanation of pollination and the necessity of a subsequent true fertilisation of a germ cell came much later.

In the time of Grew, as we have seen, the result of pollination was unknown. Vague speculation for the moment held the place of ascertained fact, and some mysterious *aura*, or *subtle influence*, was held to bring about fertility.

Following the example of the continental workers, several English botanists attempted experimentally to elucidate the problem. Of these the earliest was Bradley, subsequently the first Professor of Botany at Cambridge. In his *New Improvements in Gardening*, a work published in 1717, he gives an interesting account of an experiment performed on some tulips: "I made my first Experiments upon the *Tulip*, which I chose rather than any other *Plant*, because it seldom misses to produce *Seed*. Several years ago I had the Conveniency of a large Garden, wherein there was a considerable Bed of *Tulips* in one Part, containing about 400 Roots; in another Part of it, very remote from the former, were twelve *Tulips* in perfect Health; at the first opening of the Twelve, which I was very careful to observe, I cautiously took out of them all their Apices (Anthers) before the

Farina Fecundans was ripe, or any ways appear'd ; these *Tulips* bore no *Seed* that summer, while on the other hand, every one of the four Hundred Plants which I had let alone, produced *Seed*. As a further Demonstration that *Plants* generate after the manner I have endeavour'd to account for it, I shall recommend to my Reader the following Experiment. Make choice of such a *Plant* as the *Hazel* or *Philbad*, as you find to be in a bearing state, and far distant from any other of the same sort ; this *Tree* in *January* puts forth what are commonly call'd *Catkins*, which are long *Thrums*, compos'd of very small *Flowers* that towards the beginning of *March* are cover'd with a fine Dust ; 'tis then the *Blossoms*, or *Female Parts*, appear on the *Buds* of the same *Tree* ; they are very small and hardly to be discern'd without strict Enquiry, only offering to the View a small cluster of *Scarlet Threads*, which are so many *Tubes* leading to the Rudiments of the *Nutts* ; this happens at a windy Season of the Year, that the *Dust* may be more easily convey'd to the *Utricles*, or *Female Blossoms* of the *Plant*. Now as soon as the *Catkins* appear, they must be carefully taken from the *Tree*, and it will produce no *Fruit* that Year, unless you have a Mind to single out any particular *Blossom* of it, which may be impregnated with *Catkins* from another *Tree*, gather'd fresh every Morning for three or four days successively, and dusted lightly over it without bruising its tender *Fibres*."

Two years later Bradley pursued the subject somewhat further, inquiring into the question of hybridisation. In 1719 he said : " I believe I need not explain how the Male Dust of *Plants* may be convey'd by the Air from one to another, by which the Generation and Production of new Plants is brought about. A curious Person may by this knowledge produce such rare Kinds of *Plants* as have not yet been heard of, by making Choice of two *Plants* for his Purpose, as near alike in their Parts, but chiefly in their *Flowers* or *Seed-Vessels* ; for example the *Carnation* and *Sweet William* are in some respects alike ; the Farina of one will impregnate the other, and the *Seed* so enliven'd will produce a *Plant* differing from either, as may now be seen in the Garden of *Mr. Thomas Fairchild* of Hoxton, a Plant neither *Sweet William* nor *Carnation*, but resembling both equally ; which was raised from the *Seed* of a *Carnation* that had been impregnated by the *Farina* of the *Sweet William*."

In 1736 Bradley made further experiments in hybridisation, working on Apples with considerable success. He also investigated hybrid Auriculas.

In the edition of the *Gardener's Dictionary* which Philip Miller published in 1731, he gives an account of an observation he made upon the relation of insects to pollination. "I set twelve Tulips by themselves about six or seven Yards from any other, and as soon as they blew, I took out the Stamina with their Summits so very carefully that I scattered none of the Male Dust; and about two Days afterwards I saw Bees working on a Bed of Tulips, where I did not take out the Stamina; and when they came out they were loaded with the Farina or Male Dust on their Bodies and Legs, and I saw them fly into the Tulips where I had taken out the Stamina, and when they came out I found they had left behind them sufficient to impregnate these Flowers, for they bore good ripe seeds which afterward grew."

On the general question he says: "I separated the male Plants of a Bed of Spinach from the female, and the consequence was that the Seed did swell to the usual Bigness, but when sown it did not grow afterwards, and searching into the Seed I found it wanted the *Punctum Vitæ*, or what Geoffroy calls the Germen" (the embryo).

The views that were held in Miller's time of the process of impregnation are stated by him in his section on the generation of plants. He writes: "As to the Manner wherein the Farina fecundifies, Mr. Geoffroy (a French naturalist) advances two Opinions; First, That the Farina being always found of a sulphureous Composition, and full of subtil and penetrating Parts (as appears from its sprightly Odour) falling on the Pistils of the Flowers, there resolves, and the subtilest Parts of it penetrating the Substance of the Pistil, excite a Fermentation which putting the latent Juices of the young Fruit in motion, occasions the Parts to unfold the young Plant that is enclosed in the embryo of the Seed." Here we have very little advance upon the views of Grew; the plant in miniature is contained in the seed, and needs some subtle effluvium, aura, or perhaps juice, to enable it to develop. Miller states next the alternative view: "The second opinion is, That the Farina of the male Plant is the first Germ or Semen of the new plant, and stands in need of nothing to enable it to grow or unfold, but a suitable Nidus with the juice it finds prepared in the embryo of the seed. Mr. Geoffroy rather makes the proper Seed to be in the Farina, inasmuch as the best Microscopes do not discover the least Appearance of any Bud in the little Embryos of the Grains when they are examined before the Apices have shed their Dust." By the embryo here, the ovule is

apparently indicated. This second view is substantially that of Morland.

A somewhat clearer idea of the process following pollination was enunciated by Needham in 1750. He held that the pollen grain bursts on the stigma and that the granules it contains make their way down the style to the ovules, where they are hatched, or in some way assist in the production of embryos.

The final speculation of the period with which we are here concerned was not British, but must nevertheless be quoted in this connection. It was put forward by Koelreuter, Professor of Natural History at Carlsruhe, certainly the most capable investigator of the time. He discovered that the coat of the pollen grain consists of two distinct coats, and supposed that its contents were cellular tissue. Here we have a suggestion of the germination of the grain and the formation of the pollen tube. He thought, however, that the actual fertilising substance was an oil which exudes from the grains. Altogether his position was much in advance of the English ideas.

Apart from experimental work, the subject naturally came to the front in the literature of the time. The principal work which calls for attention is the *Botanic Essays* of Blair, published in 1720. Patrick Blair was a Scotsman who settled in London, after having been implicated in the abortive Jacobite rising in 1715. As a botanist he had already achieved some reputation. He was a devoted and somewhat pugnacious admirer of Morison, to whom he attributed the earliest proposals for a methodical arrangement of plants, in opposition to the then general opinion that priority in this particular attached itself to Ray. For most of his life he resided in Lincolnshire, where he practised medicine. He was the writer of many treatises of small value, but his chief work was the *Botanic Essays* which originated in a memoir he communicated to the Royal Society under the title of a "Discourse on the Sexes of Plants." The *Essays* were published in two parts, the first three dealt with botanical matters of a somewhat general character, the last two with the problems of sexuality and with physiological questions. The fourth essay, the only one bearing on the sex question, was prefaced by the following epitome: "On the Generation of Plants. The concurrence of the sexes necessary, variety of reasons in favour of this Doctrine. The several opinions relating to the nature and use of the Farina. Mr. Morland's opinion confuted." Though Blair did little more for botany than this, he was among the foremost men of the time.

He was a friend and co-worker with Sherard, Martyn, and the Chelsea authorities, and if not known to Linnæus, he still honoured him by naming after him the genus *Blæria*.

The gradual progress of the idea of sexuality in plants was, however, not unopposed. Its chief antagonist in Britain was Alston, Professor of Botany at Edinburgh. He published a long tirade against the theory in a volume of *Essays and Observations, Physical and Literary* in 1754. As we shall see later, Alston was a man of great learning and brilliant reputation, but, at the time, advanced in years, and somewhat isolated at Edinburgh, he unfortunately committed himself to an indefensible position. Till his death in 1760 he continued an opponent of sexuality in every shape and of Linnæus's views in particular.

It is interesting to note that though Linnæus was the great exponent of the sexual function in plants, and built upon such basis as it supplied his artificial system of classification he was not greatly in advance of the English school in his interpretation of the details and purpose of pollination. He said, "While plants are in flower the pollen falls from the antheræ, and is dispersed abroad. At the same time the pollen is scattered the stigma is then in its highest vigour, and for a portion of the day at least is moistened with a fine dew. The pollen easily finds access to the stigma, where it not only adheres by means of the dew of the part, but the moisture occasions its bursting, by which means its contents are discharged. What issues from it being mixed with the fluid of the stigma is conveyed to the rudiment of the seed."

During the remainder of the period with which this chapter is concerned, no further discovery of importance was made in England. Experiments were carried on by many botanists, and much that had already been demonstrated was confirmed. That a little development along the lines already laid down was effected comes out from the accounts of such experiments. Thornton gave instances of the work of insects in pollination, and showed how the process is dependent on them in *Aristolochia Clematitis*, the mechanism of which, with the exception of its dichogamy, he clearly understood. He also pointed out the possibility of artificial pollination by human agency. The limited knowledge of anatomy and of the process of germination of the pollen grain prevented a clear understanding of the subject.

CHAPTER XXII

VEGETABLE PHYSIOLOGY IN THE EIGHTEENTH CENTURY—*continued*

Stephen Hales

After the death of Grew the pursuit of the study of the internal structure of plants and of their characteristic physiological processes almost ceased in England. Experiments were conducted with signal success in Germany by Christian Wolff, to whom we are indebted for much of the foundation of modern physiology. Wolff published in 1723 a work which, though not dealing with these problems exclusively, presented a critical account of all that had been discovered.

Just at this juncture there appeared upon the scene another Englishman who, by his experimental work and his writings, took the foremost place in the history of the development of the new science, achieving a reputation comparable to that of Grew in the preceding century. He may indeed be regarded as the successor of Grew as he carried out with greater skill and wider insight the inquiries which Grew had proposed to himself in matters of physiology. We have seen that Grew's aims were physiological although his work was anatomical. The brilliance which he showed in the field of anatomy was by no means reflected in physiology. But the figure that now appeared was destined to shine with equal lustre in the region which Grew failed to occupy—he may in fact be called the father of vegetable physiology.

Stephen Hales was born in 1671 at Bekesbourne in Kent, and was educated at Corpus Christi College, Cambridge. He took the degree of M.A. in 1703, and was elected Fellow of his College. He took the higher degree of B.D. in 1711, while Oxford made him a D.D. in 1733.

During his Cambridge life he devoted himself in large measure to science, studying especially botany. In company with his friend Stukeley, the antiquarian, he explored Cambridgeshire with the object of rediscovering the plants of Ray's *Catalogue*. He devoted considerable attention also to astronomy and chemistry.

At the end of his Cambridge course he took orders, and in 1708 he settled down as perpetual curate of Teddington. Soon afterwards he was made vicar of Farringdon, and for more than forty years he remained living at one or other of these places, devoting his life in the first place to the duties of his clerical offices, and in the next to the prosecution of scientific research. By degrees full recognition of his distinguished merit was accorded him. In 1718 he was made a Fellow of the Royal Society, and was awarded the Copley Medal in 1739; in 1753 he was made one of the eight Foreign Members of the French Academy. He was active in the foundation of the Society for the Encouragement of the Arts and Manufactures and Commerce, now the Society of Arts, and became one of its Vice-Presidents in 1755.

Besides scientific eminence he attained a distinguished position at Court. In 1751 he was appointed Clerk of the Closet to the Dowager Princess of Wales, and was made Chaplain to Prince George, afterwards George III. He died after a short illness in 1761, and was honoured by the erection of a monument in Westminster Abbey.

His scientific works consisted of a number of memoirs read before the Royal Society at intervals during his long career of experimental research. They were gathered together during his lifetime, and published as Statical Essays, being subsequently translated into French, German, Dutch, and Italian. The first volume appeared under the title of *Vegetable Staticks* in 1727; a second, *Hæmostaticks*, being published in 1733.

When the reader's attention is drawn to a comparison between the physiological speculations of Grew and the lucid expositions of Hales, it is hard to realise that practically no one stood between them as an expounder of physiology. The fanciful theories of Grew as to the part played by the sap in physiological processes, the introduction of the idea of various kinds of fermentation by which it might be refined and elaborated, have all disappeared. Instead, we meet with accurate experiment and close reasoning. A scheme of inquiry is proposed, not vaguely, but in definite stages, following each other in orderly sequence: each answers a question suggested by the last, and in turn prepares the way for the next; above all, strict accuracy is insisted on. Hales introduced into the field of vegetable physiology the processes of weighing and measuring, leaving nothing to vague assertion or to inaccurate estimation. Herein lies the great charm of his work; there is a feeling that what results accrued may be relied

upon as a basis for further inquiry. Sachs says of him that he possessed the genius of discovery and sound original reasoning powers of the great explorers of nature of Newton's age.

It was about the year 1720 that Hales was led to the method of experiment which was productive, in his hands, of such substantial results. He says (*Vegetable Staticks*, Preface), after speaking of his early experiments on arterial pressure in animals, "I wished I could have made the like Experiments, to discover the force of the Sap in Vegetables; but despaired of ever effecting it, till, about seven years since, by mere accident I hit upon it, while I was endeavouring by several ways to stop the bleeding of an old stem of a Vine, which was cut too near the bleeding season, which I feared might kill it: Having, after other means proved ineffectual, tied a piece of bladder over the transverse cut of the Stem, I found the force of the Sap did greatly extend the bladder; whence I concluded, if a long glass tube were fixed there in the same manner, as I had before done to the Arteries of several living Animals, I should thereby obtain the real ascending force of the Sap in that Stem, which succeeded according to my expectation, and hence it is that I have been insensibly led on, to make farther and farther researches by variety of Experiments."

It is clear from this that Hales set out with the idea of the possible correspondence between animal and plant which found its expression earlier in the theory of the circulation of the sap, and that it was to the investigation of this question and its cognate problems that his early experiments were directed. In the experiment quoted we have the first demonstration of what we now speak of as root pressure, and we find Hales followed up this notable result by an inquiry into the forces of which it was the evidence. In a series of experiments arising out of it we find him demonstrating that the path of the stream is the wood, that its course is upward only, and that there is no circulation of the sap that may be compared with the vertebrate blood-stream. But he went much farther than this, for he measured the force of root pressure, he showed that it varies periodically during the twenty-four hours, and that it is influenced by changes of temperature.

Hales had an appreciation of the co-operation of transpiration (or as he called it "perspiration"), with root-pressure in the upward movement of water. In his investigation of these phenomena the importance he attached to accuracy of measurement is made

very prominent. He measured the quantities of water given off by different plants under varying conditions; he noticed especially the diminution of transpiration during the night; he demonstrated a correlation between the root and shoot with regard to the quantities of water absorbed and exhaled. In studying collateral questions connected with transpiration he investigated the behaviour of cut branches, the influence of moisture in the air on the rate of the exhalation, on the development of moulds, and coincident questions of infection, and the distribution of water in the soil, and the temperature of the latter at different depths. He introduced the method of limiting the flow of the ascending stream by ringing and by overlapping cuts, determining that a lateral as well as a vertical movement is possible. The originality and ingenuity with which he devised his experiments form a striking contrast to the work of his contemporaries and his predecessors.

In the course of his researches on the combined effects of root-pressure and transpiration he showed that the root has "considerable energy to push up sap" in the bleeding season, and that "the capillary sap vessels, out of the bleeding season, have little power to protrude sap in any plenty beyond their orifices; but as any sap is evaporated off, they can by their strong attraction (assisted by the genial warmth of the sun) supply the great quantities of sap drawn off by perspiration."

After noticing that moisture and warmth make the motion of the sap most vigorous, he continues, "Rain and warmth, after cold and dry, would make the sap rise all the next day, without subsiding, tho' it would rise then slowest about noon; because in this case the quantity imbibed by the root, and raised from it, exceeded the quantity perspired. The sap begins to rise sooner in the morning in cool weather, than after hot days; the reason of which may be, because in hot weather much being evaporated, it is not so soon supplied by the roots as in cool weather, when less is evaporated." The fall of the sap in his manometers in the middle of the day, especially on warmer days, he then declares to be due "to the greater perspiration of the branches, which perspiration decreases as the heat decreases towards evening, and probably wholly ceases when the dews fall."

He had quite a correct appreciation of the reason for the disappearance of the process of "bleeding" as soon as the leaves expand. "When towards the latter end of April the spring advances, and many young shoots are come forth, and the surface

of the vine is greatly increased and enlarged, by the expansion of several leaves; whereby the perspiration is much increased, and the sap more plentifully exhausted, it then ceases to flow in a visible manner, till the return of the following spring. . . . The sap (even in the bleeding season) is confined in its proper vessels, and does not confusedly pervade every interstice of the stem, as the rain does, which entering at the perspiring pores, soaks into the interstices, and thereby dilates the stem."

Another series of problems to which Hales directed his attention with very happy results was connected with the inter-relations between the plant and the atmosphere. He says, " Having produced many Experiments, to prove that the Air is plentifully inspired by Vegetables, not only at their roots, but also thro' several parts of their trunks and branches . . . this put me upon making a more particular inquiry into the nature of a Fluid which is so absolutely necessary for the support of the life and growth of Animals and Vegetables."

We noted that the same line of thought had been present in the mind of Grew, who, however, did little more than speculate upon it. Hales went much further than Grew: he affirmed a certain interaction of the air and the leaf, and made a definite pronouncement on its value in connection with nutrition. Though leaves were, in Hale's opinion, mainly organs of transpiration, raising the sap by suction from the roots through the stem, he was far from considering transpiration their sole function. " The leaves are very serviceable in this work of vegetation, by being instrumental in bringing nourishment from the lower parts, within the reach of the attraction of the growing fruit; which like young animals is furnished with proper instruments to suck it thence. . . . The leaves, in which are the main excretory ducts in vegetables, separate and carry off the redundant watery fluid, which by being long detained, would turn rancid and prejudicious to the plant, leaving the more nutritive parts to coalesce; part of which nourishment, we have good reason to think, is conveyed into the vegetables, thro' the leaves, which do plentifully imbibe the Dew and Rain, which contain Salt, Sulphur, etc. For the air is full of acid and sulphureous particles, which, . . . constantly forming in the air, are doubtless very serviceable, in promoting the work of vegetation; when being imbibed by the leaves, they may not improbably be the materials out of which the more subtile and refined principles of vegetables are formed. . . . We may therefore reasonably conclude that one great use of leaves is . . .

to perform in some measure the same office for the support of vegetable life, that the lungs of animals do, for the support of the animal life; Plants very probably drawing thro' their leaves some part of their nourishment from the air."

In this passage we have a remarkable instance of Hales' keen insight, for it must be remembered that at this time, many years before the work of Lavoisier and Priestley, the chemistry and the composition of the atmosphere were entirely unknown. In the passage quoted he seems to confuse the two processes of respiration and nutrition, but neither of these had taken shape in scientific thought. That he indicated the dependence of the plant on the constituents of the air for a large proportion of its food is perhaps his crowning merit as a pioneer of vegetable physiology.

Hales not only held that the air supplies something of the nature of food to the plant—he attributed to its elasticity, counteracting the attractions of other substances, the origin of the force which maintains the internal movements in the plant.

Great as was the advance that Hales made from the standpoint of Grew he did not attain anything like the modern position of physiologists. If we study his writings with the greatest care we fail to find in them any recognition of a living constituent of the plant dominating its various mechanisms. The sap seems to be the all-important thing, and its movements, its refinement under the influence of light, and its various fermentations take the place that is now given to the living substance. Hence his explanations of physiological phenomena were purely mechanical. The vagueness of Grew is not altogether absent; we find him saying of light that "it contributes to the ennobling of vegetables." His knowledge of the functions of the various organs of the plant was naturally in many respects imperfect—we can only wonder it was so extensive, for these were still the days of the infancy of anatomy as well as physiology. He apparently supported in part Aristotle's view that the food of the plant is in the main prepared for it in the soil, and lies there ready to be absorbed in the entering "sap," for he spoke of nutriment normally ascending from the root ready for the fruit. Another point on which he laid some stress was the supposed absorption of dew and rain by leaves in the ordinary course of life.

Hales did not carry out his various series of experiments from the academic point of view at all. He was deeply impressed with the importance to the practical agriculturist of studying the different phenomena of vegetable life, as may be seen in the con-

cluding chapter of the *Vegetable Staticks*. The various sciences as applied to agriculture have seen many different assignments of their relative importance. In the middle of the nineteenth century, owing to the discovery of the advantages and possibilities of artificial manures, chemistry assumed an overwhelming predominance, and the composition of the soil was almost the only problem that attracted attention, the needs and peculiarities of the various plants to be cultivated in it being held of quite subordinate importance. This view was very different from that of Hales, who, conscious of both problems, reversed the order of their importance. He wrote, "Herein therefore consists the great care and skill of the Husbandman, to adapt his different sorts of Husbandry to the very different soils, seasons and kinds of grain. . . . And probably the Husbandman might get many useful hints, to direct him in adapting the several kinds of manure, and different sorts and seasons of culture to his different soils and grains; If in the several stages and growth of his Corn, he would not only make his observations, on what appears above ground, but would also frequently dig up, compare and examine the roots of plants of each sort, especially of those which grew in different soils, and were anyhow cultivated in a different manner from each other; this would inform them also whether they sowed their Corn too thick or too thin, by comparing the branching and extent of each root, with the space of ground allotted it to grow in."

When we turn to the other section of physiology with which botanists were concerned at the time of Hales, the question of sexuality and reproduction we find him little in advance of Grew. Speculation here replaced experiment, and Hales did nothing to elucidate the problem. He wrote: "If I may be allowed to indulge conjecture in a case in which the most diligent inquirers are as yet . . . advanced but little further than mere conjecture, I would propose to their consideration, whether from the manifest proof we have that sulphur strongly attracts air, a hint may not be taken, to consider whether this may not be the primary use of the *Farina fœcundans*, to attract and unite with itself elastick or other refined active particles. That this *Farina* abounds with sulphur, and that a very refined sort is probable from the subtile oil which chymists obtain from saffron. And if this be the use of it, was it possible that it could be more aptly placed for the purpose on very moveable *Apices* fixt on the slender points of the *Stamina*, whereby it might easily with the least

breath of wind be dispersed in the air, thereby surrounding the plant, as it were, with an Atmosphere of sublimed sulphureous pounce? (for many trees and plants abound with it) which uniting with the air particles, may perhaps be inspired at several parts of the plant, and especially at the *Pistillum*, and be thence conveyed to the *Capsula seminalis*, especially towards evening, and in the night when the beautiful *Petala* of the flowers are closed up, and they, with all the other parts of the vegetable, are in a strongly imbibing state. And if to these united sulphureous and aereal particles we suppose some particles of light to be joined (for Sir *Isaac Newton* has found that sulphur attracts light strongly) then the result of these three by far the most active principles in nature, will be a *Punctum Saliens* to invigorate the *seminal* plant."

Another problem which Hales attacked with very partial success, even for the time, was the question of the growth of plants. His view was that the process is a very mechanical one, depending on the expansion of the air shut up in the interior of a somewhat extensible but solid and generally inert framework. He attributed to the power of expansion in the air the setting up of changes in the sap, whose particles consequently assume a definite form. He laid great stress on the longitudinal extension which accompanies growth, which is most noticeable in the succulent pith, and attributed it to the forcible entry of expanding air and the sap it carries with it. The extent of this force was illustrated to him by the absorption of water by swelling peas, which he carefully measured. He determined the area of longitudinal extension in shoots by the method of marking them by a series of dots, and measuring the distances between the marks after definite intervals of time.

Hales said but little on anatomical questions. He contended, however, that the bark derives its existence from the alburnum, and does not undergo any subsequent transformation. His views on the formation of bark were disproved by Knight.

In another department of physiology, that which is concerned with sensation, it may be noted that Dr. Hill wrote a pamphlet in 1757 on the so-called sleep of plants, which he showed to be due to the alternation of day and night. In it he dealt also with the cause of motion in the sensitive plant which he claimed to have explained. His work took the form of a letter to Linnæus. We shall deal with Hill's other botanical work in discussing the acceptance of the Linnean system.

An isolated experiment of some interest is recorded by Priestley in his *History of Electricity*. It is said that in 1746 a certain Mambray of Edinburgh electrified two myrtles throughout the month of October for several hours daily, with the result that in the summer of the next year they blossomed sooner than their neighbours. Nothing further appears to have been observed on this branch of physiology till quite recent times, when experiments conducted on field crops have given results which appear to confirm those of Mambray.

CHAPTER XXIII

THE ADOPTION OF THE LINNEAN SYSTEM OF CLASSIFICATION

The Work of Linnæus

THE two great physiological movements we have discussed encountered very different fates. The work of Hales remained isolated for many years, and met with no further development till the next century. The investigation into the so-called sexuality of plants resulted in great changes in taxonomy and the temporary dominance of a system of classification ostensibly based exclusively on the results of the inquiry, though, as we shall see, there was no real or necessary connection between them. Its supporters held that the system was established on the basis of a true sexual differentiation of organs. We know now that this was far from being the case, for the organs were not really sexual, and they were not used in the classification with any regard to their physiological function.

At the commencement of the eighteenth century there was very little agreement as to either the principles or the details of classification. In England the systems of Ray and Morison held the field with, on the whole, a fairly strong bias in favour of the former. On the Continent Rivinus in Germany and Tournefort in France had each put forward proposals of a certain merit, but neither of these was so distinctly the superior as to command unanimous adhesion. On the contrary, each system had its adherents, and consequently there was everywhere a great deal of confusion. Such a condition of things prepared most botanists for any scheme that would afford reasonable ground for agreement, even though it might not be scientific.

At this critical period in the history of the science, when system was really struggling to assert itself, Linnæus appeared, and although his advent had very important effects on botany in general, his influence was perhaps not so widespread in England as elsewhere. Yet even in this country he profoundly changed the current ideas on taxonomy. We may well pause, therefore, and inquire what Linnæus did for botany in its widest sense, and how he helped as well as hindered its scientific advance in England.

Linnæus was born in Sweden in 1707, two years after the death of Ray. Like so many of the pioneers of English botany his early studies were theological, but his attention was soon diverted from them to the more fascinating appeals of botanical science. In 1730 Rudbeck gave him the charge of the botanical work at Lund, including the care of the gardens. Here he began to compose some of his great works, the *Bibliotheca botanica*, the *Classes Plantarum*, and the *Genera Plantarum*. In 1732 he undertook his notable journey into Lapland, which laid the foundation of the *Flora Lapponica*. In 1735 he went to Holland where he lived three years, occupying himself entirely with botanical work. During this period he paid a visit to England and made acquaintance with its leading men of science, a visit to which in the main his subsequent influence in this country may be attributed. He also visited France during his residence in Holland. While in Holland he published the great works already alluded to, and wrote the *Systema Naturæ*, the *Fundamenta Botanica*, and other treatises. In 1738 he returned to Sweden and began to practise as a physician at Stockholm. After a stay of three years in that city he removed to Upsala where he was made Professor of Botany and where he continued to reside till his death in 1778. During his tenure of the Chair he published in 1751 perhaps his greatest work the *Philosophia botanica*, a text-book of the subject as he understood it. It was a brilliant treatise and remained unsurpassed for nearly a century. His ideas on a natural system of classification were put forward most fully in this book, though he published an important *Fragment* on the subject in 1738. His artificial or sexual system appears to have first been sketched out as a scheme in 1735, but was mainly promulgated in the books he published while residing in Holland. Linnæus's views on the morphology of the flower were strangely crude. He based it on the anatomy of the stem, holding that the cortex was changed into the calyx, the "liber" into the corolla, the wood into the stamens, and the pith into the pistil.

Linnæus has often been represented as standing between the older and the more modern botany, in a sense closing the former and opening the new chapter, and his name has consequently been held to mark an epoch. We may well inquire, therefore, more minutely what botany owes to him and what was his real position.

He co-ordinated the labours of his predecessors both in England and on the Continent, from Cæsalpino onwards, finishing and embellishing what they had left crude. By his literary skill he

presented their results in the manner of a master, so setting up a basis very fruitful in the development of the science, by welding the several fragments into a symmetrical whole. He was eminently fair and impartial in all this, giving the work of each of his predecessors ample acknowledgment, though he subjected it to criticism and analysis. So he fitted all into correct proportion and gave all its proper place and value.

He altogether reformed the art of description. It was in this field that his individuality was most pronounced. By the introduction of new and appropriate terminology he compressed into few words the long-winded descriptions that had been in vogue for so many years. His own descriptions of genera and species were models of clearness and certainty, and his points were always put most persuasively and impressively.

He practically established the binomial nomenclature of plants, replacing by clear and distinctive terms the lengthy descriptions that had hitherto been found necessary and had passed muster as specific names. This was only made possible by the care he bestowed on generic and specific diagnostic marks.

Binomial nomenclature was, however, by no means new. Centuries before Theophrastus employed something similar, but he did not use one word for the genus and one for the species in the same way as Linnæus, for the names of his genera consisted sometimes of two words.

Linnæus contributed largely to the recognition of the truth of the sexual theory as then understood, although to us in the light of fuller discovery his arguments seem poor and ineffective. They were largely based on a preconceived idea that the existence of sexuality is a necessity of the plant, and, laying all too little stress on the results of experiment, he advocated the theory on somewhat *a priori* principles.

He initiated and carried forward the idea of natural classification, as shown by his *Fragment* of 1738 and the sections in the *Philosophia Botanica* of 1751. His work in this direction has been, perhaps, rather exaggerated by the apologists of the sexual system. It is constantly said that he held the latter to be merely a temporary expedient, called for in the clash of opinion to serve while the true classification was searched for, and that he put forward advanced ideas upon the latter lines which really show him at heart to have undervalued the system with which his name is mainly associated. But when we scrutinise his ideas as set forth in the two works we have quoted we find them incomplete and

somewhat superficial. In the *Fragment*, the earlier work of the two, he arranged plants into sixty-seven orders, of which Fungi, Algæ, Mosses, and Ferns were four. In the *Philosophia Botanica* in which his ideas were more fully developed, he divided the vegetable kingdom into Acotyledons, Monocotyledons, and Polycotyledons, advancing on the lines of Ray. The suggestions he made as to subdivision of these classes were marked by considerable skill. He recognised seven great classes or families, Fungi, Algæ, Mosses, Ferns, Grasses, Palms, and Plants. In his treatment of the lower plants he was not in advance of the knowledge of his time, for he spoke of the "seeds" of Mosses, and tried to recognise in the group the same parts as in flowering plants, speaking of anthers and pistils, though he held the latter to be unrepresented in Mosses. He said that the seeds of Mosses have no cotyledons, a statement that sounds extremely strange to modern ears. The leaves of ferns he called "fronds," holding them not to be true leaves on account of their bearing the organs of fructification. He rejected the division of plants into herbs, shrubs, and trees, made as we have seen by Cæsalpino and by Ray.

His scheme was fragmentary and imperfect, for he did not devote to the subject the necessary labour and thought, nor had he acquaintance with sufficient plants to make it complete. His mind, apparently, did not dive deeply into causes of phenomena, but rather accepted them when put forward by others; indeed, he seemed to be content to classify the results that others had obtained, for he had a genius for classification, when once in possession of the necessary details. Yet it is clear that he had the right idea of the basis on which a satisfactory classification should rest, and which should underlie such details, for he said emphatically that the characters that would prove satisfactory for the purpose should not be taken from a single structure, but from a recognition of the whole.

We may emphasise two great steps of advance which were due to him: (1) The binary nomenclature, which is to be associated with the great care he bestowed on the delimitation of genera and species. Of the latter Bentham said many years later: "It was reserved for the master-mind of the immortal Swede . . . to fix . . . by the establishment of genera and species upon sound philosophical principles a firm stage to serve as a basis and standing-point for further progress and exploration. By his accurate discrimination of genera and species he really made possible the subsequent generalisations of De Jussieu and De Candolle."

(2) The idea that a satisfactory system of classification, doing justice to true affinities, cannot be founded on pre-determined marks. He accordingly sought natural affinities, but holding as he did strong views on the constancy of species, he had an altogether erroneous notion of the origination of species and varieties.

Linnæus held that a certain number of plants of the highest and of the lowest types were created at the same time and place, and that no new class of plants was created subsequently. Hence there were from the first a certain number of natural orders. By the mingling of such types a number of genera were derived, and by a mingling of genera came species, the latter giving rise to varieties by chance deviations. Hence he considered that orders, genera, and species were all fixed by Nature, and their delimitation were in no case matters of opinion. This is in opposition to the present view, which regards genera and orders as matters of judgment as to the grouping of species and of genera. He was right, no doubt, in emphasising the view that affinity must be the basis of a natural system, but with his ideas on the constancy of species he could not grasp the principle that affinity is the expression of phylogeny. He was consequently, in this particular, less a help than a hindrance to a true conception of a natural system of classification.

But the greatness of Linnæus was attended by grave drawbacks, which were in the main the direct outcome of his type of mind. He was not an investigator ; we cannot find that either he or any of his immediate pupils made a single discovery of any importance. Instead of inquiring of Nature what she had to tell, he filled his mind with prepossessions and artificial dogmas, and as new facts came into view he set himself to fit them into the dogmatic scheme. This was disastrous, as he encouraged this mode of thought in weaker minds and so materially hindered progress. The trend of inquiry had for some time been in favour of inductive reasoning, but this found no favour in the mind of Linnæus. This peculiar bent, characteristic of the old scholastic philosophy, led him to care little about the true understanding of vegetation, and to be content to accept statements made by others, so long as he might fit them into his scheme of classification. All these things were to him quite subsidiary to the art of description, of which he was such a master.

But possibly the worst disservice which he did to botany was to set up the so-called sexual system of classification. It was a temporary expedient, probably resorted to to expedite his defini-

tion and description of genera and species, and as such it stood out in marked antagonism to his declared opinion that the chief aim of botanists should be to discover the true natural system,—a system that, in his view, should ultimately rest mainly on the organs and methods of fructification. He fully admitted the unscientific character of his artificial system, which he very fallaciously styled the *sexual* system. It is possible that it was from this name that he has often been called the founder of the sexual theory. This he certainly was not, for we have seen that it was under discussion before he was born, and he certainly did nothing to establish it by experiment. Nor should his system be called sexual. It is true that it was based in the main on the number of the stamens and carpels, but these organs were considered not as sexual structures, but as morphological entities presenting a certain constancy in number and arrangement. He was strangely blind to the essential nature of a true natural system—blinded indeed by his adherence to the doctrine of the constancy of species, which he was the first to put into dogmatic form. He accepted variation it is true, but he failed to see to what it pointed. We find that while he co-ordinated the work of his predecessors he shared their fundamental errors; and through his influence these errors were maintained into the nineteenth century. His writings on the general subject were brilliant, but many of his arguments were specious and sophistical, based on philosophy and scholasticism, and very largely ignoring the results of experimental work.

The influence of Linnæus in England began with the visit he paid to this country in 1736. English or indigenous botany was at the moment at a low ebb. Dr. Sherard, the consul, was dead, Sloane was not affording it much support, while James Sherard and Dillenius were not on the most cordial terms with regard to the work at Oxford. After the publication of Ray's *Synopsis* by Dillenius in 1724 no work of any importance on the general subject appeared for many years, and no botanist of the first rank, except Dillenius and Hales, remained, while the influence of the former upon botany in general was almost negligible. There were many botanists of minor importance, but though they were well acquainted with the indigenous flora they had no grip of the great principles of the subject.

On such a scene Linnæus made his appearance, attracted to England partly by the fame of Sloane's Museum and partly by the *Pinax* of Sherard, on which Dillenius was still at work. In the course of his tour he visited the Chelsea garden and the University

of Oxford, and made the acquaintance of Petiver, Plukenet, and indeed of all the leading men of the time in England. His visit excited much curiosity, for his fame had long before preceded him. No doubt, too, it prepared the way for the promulgation of his system at a later date, for though a sketch of it had appeared in the *Flora Lapponica* in 1732 it was still a novelty.

At first Linnæus's reception in England was cool; Sloane, in particular, did not at first show himself eager to welcome him, though he brought an introduction from Boerhaave, but he changed his attitude later. Dillenius was more cordial, but his favour was the greeting of a distinguished colleague and did not carry at first any approval of his work. He wrote of him, "A new botanist is arose in the North, the founder of a new method 'a staminibus pistillis,' whose name is Linnæus; he hath printed *Fundamenta Botanica*, *Bibliotheca Botanica*, *Systema Naturæ*, and is now printing in Holland his *Characteres* and *Flora Lapponica*. He is a Swede and hath travelled over Lapponia, hath a thorough insight and knowledge of botany; but I am afraid his method won't hold."

An interesting story of the Oxford visit is traditionally preserved in the Oxford garden. When Linnæus presented himself at Oxford to Dillenius he found him in company with Dr. Shaw, the Barbary traveller, whose plants were at Oxford. Dillenius received him with a certain coolness and said to Shaw: "This is the young fellow who is putting all botanists and botany into confusion." Linnæus, though only imperfectly acquainted with English, recognised the word *confusion* from its similarity with the Latin *confusio*, but he made no comment. Walking to and fro in the garden they stopped near a wall overgrown with *Linaria Cymbalaria*, a plant upon which the two Oxonians were desirous of having the opinion of Linnæus, as some doubt had existed respecting it. Linnæus removed the difficulties with his natural perspicacity. He dealt with several other plants with equal lucidity, explaining with ease the doubtful points. Dillenius was surprised and his companion observed to him that he could perceive "no confusion at all" in Linnæus. The acquaintance between the Swede and the Oxford Professor, begun thus unfavourably grew rapidly, the coolness speedily vanished, and cordial regard arose between them. When Linnæus took his leave he banteringly alluded to the incident, and remarked that he should be very sorry to have brought *confusion* into the garden at Oxford. Dillenius at once apologised for the hasty word which had escaped his lips.

Linnæus's visit to Oxford led to the maintenance of a firm friendship with Dillenius. On his return to Holland he dedicated to him the *Critica Botanica*, which he published the next year. On his side Dillenius became so attached to his visitor that he used all his powers of persuasion to induce Linnæus to take up his residence in England.

At Chelsea Linnæus made the acquaintance of Miller, of whom he formed a high opinion both as gardener and botanist. Miller, like Dillenius, was not at first in favour of the new system, but ultimately he adopted it, being convinced of its utility mainly by the arguments of Sir William Watson and Mr. Hudson, the latter being especially enthusiastic about it, and indeed bringing it before the public eye by arranging his *Flora Anglica* according to it.

After Linnæus returned to Holland he published a series of books which contained a much clearer exposition of his system than the preliminary sketches that had appeared in 1732 and 1735. In the *Critica Botanica*, dedicated as we have said to Dillenius, he explained his reasons for changing names and establishing new distinctions in the cases of genera and species. The *Flora Lapponica*, the *Genera Plantarum*, the *Hortus Cliffordianus*, and the *Systema Naturæ* all contained his views more and more clearly set forth. As these books made their way into England the simplicity of the method, combined with the precision his power of description gave to the distinctions of genera and species, commanded the assent of the less scientific and particularly of the unreflecting, and paved the way to its general acceptance by English botanists.

As propounded then, the Linnean system was that outlined on pages 216 and 217.

It clearly aimed at finality, and left no room for any essential modification—a kind of soporific to stifle inquiry.

It is strange that the name of Linnæus should to-day be primarily associated with this, the only part of his work which was unworthy of his great reputation. Who now thinks of him as the genius who cleared up the question of nomenclature, who substituted simplicity and terseness for the tedious descriptions that once passed for names, who brought the art of description to something nearing perfection, and who placed genus and species on a definite basis, and demonstrated their proper relations? For one who thus thinks of him a hundred will picture him to themselves as the advocate and exponent of that absolutely unscientific

and abortive system of classification to which his name unhappily must remain for ever attached.

Reviewing the system of Linnæus as set out, we ask: What are its advantages? Pulteney probably expresses the opinions of those who advocated its adoption in England as well as his own personal feeling. Writing in 1790 he claims as its great merit its extreme simplicity, and the precision which marked the definition of species. The latter was no essential part of it, for a scheme of classification must be in the end a classification of species into larger and yet larger groups. This then must be common to both artificial and natural systems. We thus arrive at the view that its simplicity was its great charm. It met the wants of and appealed to men who were bewildered and fatigued by the complexities inseparable from the other schemes then extant, each country boasting its own, each sheltered behind a great name—Ray, Tournefort, Rivinus. Surveying them all, they felt oppressed by the apparent irreconcilability of their proposals. The Linnean proposals offered a rest from controversy, and so made a powerful appeal to minds who wanted rest and peace instead of continuous discussion, finality instead of the search for and possible discovery of truth. It appealed to the indolent rather than to the enthusiastic, and hence, no doubt, it secured assent. Not that it was immediately embraced; in England, at any rate, it had to make its way but slowly against powerful opposition brought to it by the older botanists trained in the school which paid reverence to the memory of Ray. Even up to the end of the century when it was generally accepted many absolutely declined to adopt it.

TABULAR VIEW OF THE LINNEAN

- Plants having
  - Stamens and pistil evident
    - Stamens and pistils in the same flower
      - Stamens separate from the pistil
        - Stamens not connected with each other
          - Stamens of equal length (or at all events neither didynamous nor tetradynamous)
            - 1 stamen
            - 2 stamens
            - 3 ,,
            - 4 ,,
            - 5 ,,
            - 6 ,,
            - 7 ,,
            - 8 ,,
            - 9 ,,
            - 10 ,,
            - 12-19 ,,
            - 20 or more perigynous
            - 20 or more hypogynous
          - Stamens of unequal length
            - Two long and two short stamens
            - Four long and two short stamens
        - Stamens united to each other
          - By their filaments in one bundle
          - By their filaments in two bundles
          - By their filaments in more than two bundles
          - By their anthers
      - Stamens adherent to the pistil
    - Stamens and pistils in separate flowers
      - On the same plant
      - On separate plants
      - Stamens and pistil separate in some flowers and united in others, either on the same or on two or three different plants
  - Organs of reproduction concealed or inconspicuous

ARTIFICIAL OR SEXUAL SYSTEM

Classes	Orders	
1. Monandria	1. Monogynia	1 free style or stigma
2. Diandria	2. Digynia	2 free styles or stigmas
3. Triandria	3. Trigynia	3 ,, ,,
4. Tetrandria	4. Tetragynia	4 ,, ,,
5. Pentandria	5. Pentagynia	5 ,, ,,
6. Hexandria	6. Hexagynia	6 ,, ,,
7. Heptandria	7. Heptagynia	7 ,, ,,
8. Octandria	8. Octagynia	8 ,, ,,
9. Enneandria	9. Enneagynia	9 ,, ,,
10. Decandria	10. Decagynia	10 ,, ,,
11. Dodecandria	11. Dodecagynia	12-19 ,, ,,
12. Icosandria	12. Polygynia	20 or more free styles or stigmas
13. Polyandria		
14. Didynamia	1. Gymnospermia.	Fruit achænia with one seed
	2. Angiospermia.	Fruit capsular with many seeds
15. Tetradynamia	1. Siliculosa.	Fruit a silicula
	2. Siliquosa.	Fruit a siliqua
16. Monadelphia	1. Triandria	3 stamens
17. Diadelphia	2. Pentandria	5 ,,
18. Polyadelphia	3. Hexandria	6 ,, etc., etc., as in first 13 classes
19. Syngenesia	1. Polygamia æqualis.	Florets in capitula and all perfect
	2. Polygamia superflua.	Florets in capitula; florets of the disc, hermaphrodite; of the ray, pistillate
	3. Polygamia frustranea.	Florets in capitula; those of the disc, hermaphrodite; those of the ray, neuter
	4. Polygamia necessaria.	Florets in capitula; those of the disc, staminate; those of the ray, pistillate
	5. Polygamia segregata.	Florets in capitula each with a separate involucre
20. Gynandria	1. Monandria.	1 stamen
	2. Diandria.	2 stamens, and so on, according to the number of stamens, as in the first 13 classes
21. Monœcia 22. Diœcia	1. Monandria.	1 stamen
	2. Diandria.	2 stamens, and so on, as in the first 13 classes
	3. Monadelphia.	Stamens united into one bundle by their filaments
	4. Polyadelphia.	Stamens united into several bundles by their filaments
23. Polygamia	1. Monœcia,	with staminate, pistillate, and hermaphrodite flowers on the same plant
	2. Diœcia,	with hermaphrodite flowers on one plant and staminate and pistillate flowers on another plant
	3. Triœcia,	where one plant bears hermaphrodite, another staminate, and a third pistillate flowers
24. Cryptogamia	Ferns, Mosses, Algæ, Fungi	

CHAPTER XXIV

THE ADOPTION OF THE LINNEAN SYSTEM—*continued*

Controversy

LINNÆUS'S proposals found in England a condition of unrest in botanical thought. As we have seen, no progress of any very great value in matters of classification had been made since the death of Ray, and no one, with the exception of Martyn the elder, was living who showed any particular interest in the question. Still the younger men were by no means satisfied, and many of them hailed very heartily the new proposals. There sprang up, however, a somewhat acute controversy as to the propriety of accepting them in place of the natural system, incomplete as it was, and advocates of both made their appearance in a very short time.

Among the followers of Ray may be mentioned especially an amateur of considerable ability, John Wilson, who first published Ray's *Synopsis* in English. He was born in humble circumstances, and owing to his absorption in botanical work, he remained a poor man all his life. Though he was self-educated he made himself familiar with Latin to enable him to read the botanical works of the older writers. He lectured a good deal in the North of England, but his chief contribution to science was the work alluded to above, the preparation of an English edition of the *Synopsis*, published in 1744 as a counterblast to the Linnean literature. In this translation he re-wrote Ray's descriptions, giving additional characters, part of which he derived from Tournefort, and part he devised himself. His own contributions were, in the light of modern research, of doubtful value. He linked the Fumariaceæ with the Papilionaceæ, loaded up the Siliquosæ (Cruciferæ) with sundry genera not at all related to them, and indeed completely upset Ray's twenty-second class. On the other hand he distinguished *Chelidonium* from *Papaver*. Wilson died in 1750 while the effort to establish the Linnean system was still short of success.

Another name of note is that of Blackstone, an apothecary in London, who published several works all based upon the system

of Ray. The first was a local flora of Harefield, a book not of much importance ; the second was, however, a valuable edition of Ray's *Synopsis*, containing the localities of nearly 400 species of the rarer English plants. It was called *Specimen Botanicum*, and is specially noteworthy as being the last book on English botany that was published before the system of Ray may be considered as superseded by that of Linnæus. Of less note was Dr. Deering, a resident at Nottingham, who was nevertheless very assiduous in exploring the flora of that district. He published a local flora of some merit, which contained many references to the Cryptogams.

Opposition to the proposals of Linnæus was conducted, as we have already seen, by Professor Alston in the University of Edinburgh. But on the other side were ranged most of the younger men impatient of the incompleteness of Ray's proposals, but not possessing sufficient insight into affinity to be able to complete or even to extend them. It is hardly to be wondered at that as time drew on and the older botanists—the friends of Dillenius and Martyn—gradually disappeared from the scene, the new classification made its way and gradually prevailed, till about 1760 it became generally adopted. During the controversy several advocates of it appeared helping it onwards. Among them a place must be given to a distinguished amateur, Sir W. Watson, a friend of Sir Hans Sloane in his later years, and a man who helped materially to influence the mind of Philip Miller, the great Chelsea botanist.

Watson

Watson was born in 1715, and after his schooldays, passed at Merchant Taylors', was apprenticed to an apothecary. In his youth he was an enthusiastic field-botanist, working in the early mornings at exploration and research, till he was thoroughly familiar with the plants of the neighbourhood of London. In proof of the ardour of his pursuit of botany it may be mentioned that he won the coveted copy of Ray's *Synopsis* given annually by the Apothecaries' Company for proficiency in the subject. This earnestness of purpose and indomitable energy followed him throughout his life and helped to make him one of the most conspicuous figures of his age.

He went into business in 1738, but still devoted his leisure to scientific pursuits, and achieved a great reputation not only or

even mainly as a botanist, but more especially as a student of electricity.

Settling down in London he contributed numerous papers to the *Philosophical Transactions* of the Royal Society, most of them in his earlier days being on botanical subjects. His earliest paper was an account of Haller's *Flora of Switzerland*, which he translated into English and illustrated with a Conspectus of the author's method and with criticisms of his own. He followed this by some valuable work on the Fungi, attracting considerable attention from the botanists of the Continent by a description of the fungus *Lycoperdon*, illustrated by an engraving of the plant. In the same volume of the *Philosophical Transactions* he published a memoir on some of the poisonous plants grouped among the Umbelliferæ, a subject to which he returned some years later. His papers on this group attracted much attention, written as they were with great skill and displaying much acumen in diagnosis. They were illustrated by the famous draughtsman Ehret. Watson also contributed papers on the poisonous properties of the yew and of the black henbane.

He did good service to the cryptogamic side of botany by showing to the English public that the organisms known as zoophytes are not vegetable in nature. The discovery was not his, but was made in 1723 by Peyssonel. The latter writer sent his treatise in manuscript to the Royal Society, and it was referred to Watson, who translated and abridged it and prepared it for publication in the *Philosophical Transactions*.

But Watson's influence in the movement now under consideration was due to an account of the *Species Plantarum* of Linnæus which he contributed to the *Gentleman's Magazine* in 1754. This was brought to the notice of the great Swede and received many encomiums from him. It was not a mere notice of the work, but contained a critical examination which was marked by great skill and considerable candour. Coming from Watson it was of great service to the advocates of the new system. From this time onward Watson was the recipient of many distinctions. In 1745 he had been awarded by Sir Hans Sloane, as surviving executor of Sir Gilbert Copley, the Copley Medal of the Royal Society, chiefly for his electrical work. Sir Hans also nominated him as one of the trustees of the British Museum, and on its taking possession of its new home in Montagu House in 1756 he took a large share in making the internal arrangements and in furnishing the gardens. For his eminence in medicine he was made M.D. by the

Universities of Halle and Wittemberg almost simultaneously in 1757, and he was elected a Member of the Royal Academy of Madrid. He sat frequently on the Council of the Royal Society, and was a Vice-President for several years. In 1784 he was made a Fellow of the Royal College of Physicians, and was Censor of the College in 1785 and 1786. He received the honour of knighthood in 1786, a year before his death.

Watson's knowledge of plants and of the literature of botany was so extensive that he was known among his friends as "The living Lexicon of Botany." In private life he was conspicuous for his benignity, affability, and readiness to help all with whom he came in contact.

Sir John Hill

Another figure of some note during these years was that of Dr. Hill, a man who amid much bad work did a few things of considerable merit. Hill was said to have been born at Peterborough in 1716, and was apprenticed to an apothecary, setting up in business at Westminster as soon as he was qualified to do so. He travelled a good deal over various parts of England, and became known as a botanist of considerable attainments. He was employed by the Duke of Richmond and by Lord Petre to arrange their gardens and collections. Ultimately he obtained a diploma of medicine from the University of St. Andrews. In 1774 he was made a member of the Order of Vasa by the King of Sweden, in recognition of the merit of his *Vegetable System*, then in course of publication. Thenceforward he called himself Sir John Hill. His scientific attainments seem to have been estimated by himself more highly than by the scientific world of England, for he was refused admission to the Royal Society when he was a candidate for its fellowship. Though this may, perhaps, have been due to personal dislike, it was the cause of much chagrin to him and he took his revenge by attacking the society in several satirical pamphlets, holding especially the *Philosophical Transactions* up to ridicule.

This naturally did not increase his popularity, and he became looked upon as a charlatan by the leading men of the time in other fields than science; many of them treating him in their writings with scarcely veiled contempt.

It is not, however, with his general life that we are concerned here, but only with his influence on botanical thought. His work was of very unequal value, and not much of it possessed

real merit. In 1751 he published a *History of Plants*, which was based principally on Linnæus's writings. In 1759 he began to bring out his *Vegetable System* which was to be in twenty-six folio volumes, with 1600 copper-plate engravings, representing 26,000 plants. It was ultimately completed in 1775.

In 1759 he contributed a work on exotic botany in support of the sexual system, and in 1760 he followed this by his *Flora Botanica*, which was a rearrangement of Ray's *Synopsis*, according to the Linnean system. This was the first work thus arranged by an English pen, and is worthy accordingly of a place in the literature of the time, but it was a poor production. In 1768 he wrote "Hortus Kewensis, sistens herbas exoticas, indigenas que rariores in area botanica apud Kew cultus," one of the earliest works associated with Kew. Some years later Lord Bute proposed to make him Superintendent of the Royal Gardens, but the appointment was not confirmed.

Hill's acquaintance with botany was not confined to questions of taxonomy, but extended to anatomy and physiology as well. While it cannot be claimed that he made any very important discoveries in these directions, he was certainly in advance of most of his contemporaries in the assiduity with which he carried out his observations. He, in some ways, took up a line similar to that of Grew in the preceding century, and, to a certain extent, carried further the investigations in anatomy which had occupied his great predecessor. He studied with great care the trunks of trees and endeavoured to sketch certain features of their comparative anatomy. He grasped many of the features of secondary thickening though he knew nothing of cambial activity. He appreciated, to some extent, the differences between the outer and inner zones of the annual ring though he put forward no explanation of them. His ideas of cellular structure did not go far beyond Grew's, nor were his views correct as to the nature of the cell. His book on the *Construction of Timber*, published in 1770, was certainly noteworthy for the time.

His most notable contribution to physiological knowledge was his investigation into the behaviour of the sensitive plants, in the course of which he indicated that the action of light on the pulvini of the leaflets played a conspicuous part in the movements they displayed. He could, however, hardly be said to have grasped the principle of stimulation and response, for his explanations were mechanical. Still he noted that the fall of the leaflets could be brought about by contact and by differences of

temperature as well as of light. He investigated also the phenomena of the so-called *sleep* of plants, and made some observations on reproduction, showing himself an adherent of the views of Morland.

On the whole Hill's writings were not of any particular value. They contained some good work, but it was overshadowed by much that was inferior. He left, at his death in 1775, no permanent mark upon the literature of botany.

When we review the literature of the period which followed the visit of Linnæus and the appearance of his writings here, a gradual change in the leading text-books may be noticed, which grew very pronounced after about 1750. In 1754 Ray's *Synopsis* was rearranged by a Swedish writer and his plants classified on Linnean lines. Hill's writings, though of doubtful value, must receive recognition as belonging to this period. In 1759 Stillingfleet published a translation of several tracts from the *Amœnitates Academicæ*, in which by means of his own notes and comments he did much to advance the progress of the artificial system. In the same year Miller produced the seventh edition of his *Dictionary*, which for the first time was modelled on Linnean lines. Also in 1760 Lee helped to popularise the system by translating Linnæus's *Elements*. Linnæus's favourite pupil, Solander, came to England in 1760, and being personally familiar with his proposals in great detail, he advanced its adoption by his great personal charm and by his skill in advocacy.

A new English flora, written by William Hudson of Chelsea, to whom we shall refer in the next chapter, was published in 1762. This *Flora Anglica* was arranged according to the Linnean system, and, under the influence of the new ideas, it was at once adopted as the standard text-book, supplanting the *Synopsis* which had held that place for many years.

The final rout of Ray's system may be traced to the efforts of two of the foremost teachers of the time. The first of these was Thomas Martyn, the son of the Professor of Botany at Cambridge, to whom we shall refer in fuller detail later. In his father's absence many of the duties of the Cambridge Chair were discharged by him, and in 1762 he succeeded to the Professorship. He was an enthusiastic follower of the great Swede, and did much to bring about the acceptance of his system. The other was Dr. Hope, Professor of Botany at Edinburgh. As we have seen, Alston opposed the system with much energy during his life, but at his death in 1760 Hope succeeded him. He was of a totally different

way of thinking, and in all his university work he promulgated the new proposals. At Oxford no opposition arose; indeed, botany at Oxford, then under Humphrey Sibthorp, was in a very languishing condition.

We may take it, therefore, that under the slow changing of public opinion, the alteration in the books, and the active teaching of Martyn and Hope, the year 1760 may be considered the date at which the adoption of the Linnean system was achieved, and at which, for the moment, the true scientific spirit of inquiry and research was driven into the background. The scheme seemed to offer to those who accepted it a certain finality, and to abolish the necessity of arduous, assiduous, and difficult investigation. Its advocates in England went far beyond their master, who did not really approve of his own proposals, but regarded them as merely temporary. The soporific effect it had upon the progress of inquiry was very grave, as we shall subsequently see. But who were the men who took it up so keenly? No botanist of the first rank—not a single man who stands out to this day as a leader! Dillenius would have none of it—Thos. Martyn, Miller, Hudson, Hope—shortsighted men who hailed a temporary deliverance from the necessity of prolonged but fruitful research. So the clock was put back for a generation, with the result that botany sank lower and lower in the scale of the sciences, and lost more and more of its popularity, till it was a general complaint that its students were falling off almost to extinction.

The difference in opinion between Linnæus and his English followers is seen to be most marked when we read the extravagant eulogies which many of them passed upon his system. Miller, reluctant as he was to accept it at first, said later that it was much preferable to all the systems of botany that had up to that time appeared, for two reasons: First, because of all the systems proposed there was not one of them that approached so nearly to the ideal as this one, most of the classes being so very natural. Secondly, because it was founded upon the parts of the plants which are most constant and least subject to variation, the stamina and pistils, which are the true organs of generation. Hudson in his *Flora Anglica* after acknowledging his obligations to Ray's *Synopsis*, went on to say: "A new star has arisen in our days which has shed a light not before seen even in dreams, on the Botanical world; namely that great Linnæus, who by bringing to view, by fully illustrating and by correctly naming, the most minute parts of plants which had either been previously neglected,

or had never been observed, has laid the foundation for a new and simple, concise, and certain method which he has happily applied with an admirable consistency to the whole vegetable kingdom hitherto known." Pulteney writing in 1790 called it "a system which had given the author of it a literary dominion over the vegetable kingdom, which in the rapidity of its extension and the strength of its influence had not perhaps been parallelled in the annals of science." Its supporters thought it had achieved finality and was so near perfection that they did not hesitate to decry all attempts to amend it. Such attempts were made in the early years of the nineteenth century by Sir J. E. Smith and by Withering, but they met with such strong opposition that they were abandoned, and the system remained to their gratification as it left the pen of its illustrious author.

Before dismissing the subject of the adoption of the Linnean system in England some mention should be made of a contributor to the scheme who, though not a botanist, achieved a very high degree of fame by the use of his pencil in connection with the subject. This was Georg Dionysius Ehret, the finest draughtsman of his day, who was the first to emphasise in his drawings the principles underlying the proposals of Linnæus.

Ehret

Ehret was the son of a gardener at Erfurt where he was born in 1708 or 1710, and was brought up to his father's avocation. At a very early age he showed great skill in the art of delineating and painting flowers, and his wonderful talent was recognised while he was but a young man by Dr. Trew of Nuremberg, who has already been alluded to in connection with Mrs. Blackwell's *Herbal*. Trew sold young Ehret's drawings to Dr. Wiedmann of Nuremberg, securing him an artistic career. He travelled a good deal through part of Europe, living in turn at Basle, Montpelier, Lyons, and Paris. In the last-named city he became acquainted with Linnæus's great contemporary and rival, De Jussieu, and was employed by him at the Jardin des Plantes. He shortly afterwards left Paris for London, but after a very short stay returned to the Continent, taking up his abode first at Leyden and then at Haarlem where Linnæus found him employed in Clifford's garden. Different as were their relative positions, an acquaintanceship sprang up between them, which ripened into friendship, and the great Swede induced the painter to turn his attention to the study

of botany. Linnæus subsequently employed him to draw the illustrations of the *Hortus Cliffordianus* of 1737 which has already been noticed.

Ardently attached to his patron, Ehret returned to England in 1740, and with his pencil lent great assistance to the acceptance of the Linnean system in this country. He married the sister-in-law of Philip Miller, and lived in England till his death in 1770. During the thirty years of his residence here he was on intimate terms with the leading botanists of the country, including Sir Hans Sloane, and he found many influential patrons. It is estimated that he painted nearly 3000 species for various gentlemen, and he numbered many members of the aristocracy, among them the Dukes of Norfolk and Leeds, among his pupils. Some of his works were published in the *Philosophical Transactions*, illustrating memoirs by Sloane, Watson, and others. His contributions to the advancement of science thus made were rewarded by his election to the Fellowship of the Royal Society in 1757.

His career in England was on the whole uneventful. In 1750 he was given an official position at the Botanic Garden at Oxford, through the influence of Professor Humphrey Sibthorp, but the latter becoming jealous of him after about a year, he left Oxford, taking with him a sense of having been treated with great unkindness. About 1754 he was offered the post of draughtsman to the Botanic Garden at Copenhagen by Dr. Œder, the Professor of Botany, but he preferred to remain in England. His main works were illustrations to various botanical books, the chief of which were: *Plantæ et Papiliones selectæ*, 1748-59; Trew's *Plantæ selectæ*, of which ten decades were published between 1750 and 1773; Ellis's *Corallines*, 1755; Brown's *Natural History of Jamaica*, 1756. Many of his drawings came into the possession of Sir Joseph Banks and are now in the British Museum, as are also some of his manuscripts.

BOOK IV

THE ASCENDENCY OF THE LINNEAN SYSTEM

BOOK IV

CHAPTER XXV

CAMBRIDGE UNDER THOMAS MARTYN

We have seen the gradual replacement of the natural system of classification so far as it was modelled by Ray and his successors by the so-called sexual system of Linnæus, and have recognised how greatly this change was due to the influence and teaching of Thomas Martyn, perhaps the most prominent figure in the botanical world in England at the time of its adoption, about 1760. Not that he stood alone; his father, the Cambridge professor and the friend of Dillenius, Miller of Chelsea, Hudson the coming taxonomist, and others were all living at the time, but age was telling its tale, and many were retiring from active work. Younger men there were too, but none at the moment of particular mark.

Prominent as was the personality of Thomas Martyn at this period we cannot compare him with the illustrious figures that we met fifty years earlier. It did not fall to him to lead the strenuous life of the pioneer of science. His lot was cast in easier places, and in the life of the university student, professor, and country clergyman he carried out such botanical work as came to him. He did little that was original, but he developed considerably the work of others, and helped largely to popularise the subject. Possibly the greatest thing that can be associated with his name was the introduction and establishment of the Linnean system, which we have already seen was the achievement of his earlier years.

The son of Professor John Martyn, he was born in 1735, and was educated at Emmanuel College, Cambridge, entering in 1751 and graduating in 1756. He pursued the usual path of study at Cambridge, studying first mathematics and then turning his attention to theology. In those earlier years he had little thought of a botanical career, though as the son of his father he was naturally interested in the science. In the preface to one of his works he

says, "Being then (1753-56) engaged in academical studies and afterwards (1756-59) in those of the profession I had determined to adopt, Botany was rather the amusement of my leisure hours than my serious pursuit, till the institution of a Botanic Garden at Cambridge by Dr. Walker, and the desire which my father expressed to resign a chair which his age and infirmities rendered him unable to fill with satisfaction to himself, roused my attention a second time to a favourite pursuit."

In the year of his graduation he was elected to a Fellowship at Sidney-Sussex College, Cambridge, and two years later was ordained. In 1760 he was made tutor of his college, a position he retained for fourteen years till his marriage.

The quiet course of his life was broken in upon by the resignation of his father in 1762. During these years he had been very active in botanical exploration in the neighbourhood of Cambridge, studying both the phanerogamic and the cryptogamic vegetation, and so began to make a reputation as a botanist. He was consequently elected to succeed his father in the Chair of Botany.

It was during these years of academic life that he took the active part he did in bringing forward the Linnean system, and once seated in the Chair he introduced it in his public lectures. He says, "Having been appointed by the unanimous voice of the University of Cambridge to the Professorship of Botany, and being soon after nominated by Dr. Walker, the founder of the new garden, his first Lecturer; I had the felicity of taking the lead in introducing the Linnean system and language to my countrymen by a course of public lectures." We learn that this course was attended by fifty pupils, and about as many occasional hearers. Martyn was thus the first public advocate and the earliest promulgator of the Linnean system in an English university.

In 1763, the year of Lyons' *Cambridge Flora*, the fruit of Martyn's herborising explorations saw the light in the form of a volume which included two works: "Plantæ Cantabrigienses, or a Catalogue of the Plants which grow wild in the County of Cambridge, disposed according to the System of Linnæus," and "Herbationes Cantabrigienses, or Directions to the places where they may be found, comprehended in Botanical Excursions." This, which has perhaps better claims than Lyons' book to be considered the third Cambridgeshire flora, was the first local flora to be arranged on Linnean lines, though it was preceded by a year by Hudson's larger work, the *Flora Anglica*. In it he added 181 new plants to his father's work, making the total number of additions to

Ray's *Catalogue* 907. In the *Plantæ Cantabrigienses* the arrangement is according to the Linnean classes, but in three parallel columns :—

1st. The generic and trivial names of Linnæus.
2nd. The name with reference to the page of his father's *Methodus Plantarum.*
3rd. The name in Ray's *Alphabetical Catalogue.*

For some years Martyn's hands were very full with the duties of his Chair. The garden which was then associated with the Professorship was a source of much effort and considerable anxiety. Though it had been founded its equipment was of the most meagre order, and upon the Professor fell the larger share of its organisation and development. For seven years he was assisted in his duties by Mr. Charles Miller as Curator, a son of Philip Miller, the great gardener of Chelsea. But in 1770 Miller left Cambridge for the East Indies, and in default of a capable successor the Professor added the duties of Curator to those which he had already undertaken, so that the sole charge of the subject in the University devolved upon him. In 1771, finding that a manual of the garden was badly wanted for his pupils, he issued a "Catalogue of the Garden," together with an outline of his lectures, and he followed it up by publishing a further catalogue next year. It was on these two lists that Donn founded the *Hortus Cantabrigiensis*, which some years later was completed by Lindley. To this second catalogue a plan of the garden was prefixed. "The usual entrance to the garden was from Free School Lane through a small Renaissance archway. . . . There was a second entrance from Pembroke Street. . . . From these gates a broad gravel walk led straight across the Garden to the centre of a range of greenhouses built against the north wall. At a distance of about 175 feet from the gates this walk was carried by a wooden bridge over a long narrow pond, which crossed the Garden from east to west and divided it into two unequal divisions. That between the pond and the street contained the herbaceous plants, arranged in a series of herbaceous parallel beds ; that between it and the greenhouses was laid out in other beds, not quite so formal, for less hardy plants. . . . Before the above-mentioned gates in Pembroke Street were set up, the entrance to the Garden on that side was through a small doorway at the south-west corner, the traces of which may still be seen in the boundary wall."

The development of the garden was largely Martyn's work,

but it was a very slow and tedious task, being hindered by the lack of funds. Its condition, even at the end of his life, was very unsatisfactory. A year before his death Dr. Schultes, a professor from Bohemia, made a botanical tour, in the course of which he visited it, and in a letter to Count Sternberg, to be found in Hooker's *Miscellany* for 1830, he writes: "The garden at Cambridge contains about 5 acres of very bad ground, and there are from 5000 to 6000 species of plants, the greater part of them cultivated in beds. It does not present so pleasing an appearance as the Dutch botanic gardens, but is however kept very neat, and is well arranged. . . . The care of the garden is committed to Mr. Briggs whom we did not find at home. The stoves are well built and they may have been hitherto large enough; but the progress of the science will soon cause their size to be insufficient, as they extend only to 216 feet. A building was erected some years ago for the lecture rooms of the professors of botany, chemistry, mineralogy, and mechanics. The Alpine plants, among which are some rare species from the South Highlands, are very properly cultivated in small pots, and placed during winter under glass. The assistant gardener who conducted me through the ground was not able to tell me the annual expenditure of the institution. The work people receive two shillings a day."

But this slow development was no fault of Martyn's. He did his best, at personal sacrifice, accepting no remuneration when, after Miller's departure, he for several years discharged the duties of Curator. The terms in which he announced his first course of lectures of 1763 show the attitude he took at the outset, an attitude he always maintained. In the *Cambridge Chronicle* of March 16, 1763, the following announcement appeared: "On Monday, April 18, at the great House in Free Schole Lane, will begin a course of lectures by T. Martyn M.A. Prof. The first course 2 guineas, the 2nd course 1 guinea, ever after gratis. The Lectures will begin exactly at 2 o'clock. Gentlemen who propose to attend are desired to send in their names. Note.—The Professor intends to read gratis to those who subscribe 10 guineas towards the support of the Botanic Garden."

Martyn continued to reside in Cambridge till 1774, when he married. By this course he vacated his Fellowship at Sidney, and he consequently removed to Triplow in the County, having at the time of his marriage accepted the living of Foxton, an adjoining parish. After a stay of two years there he left the County and went to live at Little Marlow, in Buckingham-

shire, to which living he had just been presented. His active career at Cambridge as Professor thus lasted thirteen years. During this time he continued as assiduously as he could his botanical exploration of the County, having it in his mind to bring out a thoroughly new flora arranged on the Linnean system. Circumstances, however, prevented his publishing his results, and he kept them by him, waiting for a favourable opportunity till 1783, when he finally abandoned the idea, and handed over his manuscripts to his friend, the Rev. Richard Relhan, Fellow of King's College, who had been for some time engaged on a similar enterprise. Relhan's *Flora Cantabrigiensis*, which was published in 1785, the fourth flora of Cambridgeshire, or the fifth, counting the small work of Lyons, embodied thus the discoveries of Ray, of the two Martyns, of Lyons, and of the indefatigable author himself, and was for very long the standard authority on the subject. Appendices to it were brought out in 1786, 1788, and 1793, and the whole contained 383 new plants found in the County since 1763. A second edition added 132 more in 1802, and contained the names and descriptions of 1344 plants. This number was increased by 75 more in 1820, when a third edition appeared. Relhan's work was particularly noteworthy from the great number of Cryptogams which he included, mainly his own discoveries.

Though he left the County in 1776, Martyn retained his Chair, and continued to visit Cambridge annually for a further twenty years to give his course of lectures. It was not, however, quite without intermission, as circumstances prevented his doing so in 1779, 1780, and 1785.

Naturally his removal from the sphere of his university work made a considerable difference in the form of his activities. From this point, after an extended tour on the Continent in 1778, 1779, and 1780, he seems to have given up active botanical work, to have stood somehow aside from the pursuit of the science, and to have retired to his study. Not that he was in any way lost to botany however, for he entered like Ray upon a period of literary activity.

In the winter of 1784-85 he left Little Marlow for London, and took up his residence in Westminster. In the following summer he published what seems to have been his most popular work, his "Letters on the Elements of Botany, addressed to a Lady by the celebrated J. J. Rousseau ; translated into English with notes and twenty-four additional Letters, fully explaining the System of

Linnæus." Three years later appeared another volume, bearing the title, "Thirty-eight Plates, with explanations; intended to illustrate Linnæus's System of Vegetables, and particularly adapted to the Letters on the Elements of Botany."

It is in consonance with the modesty which was associated with the Martyns, father and son, that the credit of this work was given so prominently to Rousseau. As a matter of fact only the introduction and eight of the lectures were from his pen, and the literary and scientific merit of the latter part far exceeded these. In them Martyn's views on teaching are to be found; it is particularly interesting to find him telling his supposed "Lady" pupil to go direct to Nature for her information; to study the structure of the various plants she may find, and not to pin her faith to the "ipse dixit" of any teacher, however eminent, nor to the text-books of her time. Nothing sounder can be advanced even at the present day.

This work occupied its author only a year and it was followed by the undertaking which occupied the remainder of his life. This was a new edition of Miller's great work, the *Gardener's Dictionary*, which he agreed to prepare for Messrs. White and Rivington after Curtis had declined the task. Martyn modestly allowed it to pass under Miller's name, but it was practically a new work upon Miller's lines, and was made as complete a book of reference as was possible. It embodied the results of Linnæus, and was arranged in the main upon his system. It might be said, indeed, to have been a presentation of the state of botany at the close of the eighteenth century, just as Ray's *Historia* represented its condition a hundred years earlier. Though Miller's original book was, as we have seen, intended mainly for gardeners, it had distinctly its botanical side, and Martyn was at pains in his presentation of it to keep the horticultural and the botanical parts distinct. He added a large number of plants to its contents, giving descriptions of species in the higher plants and of genera in the Mosses and Thallophytes. The parts of the book which dealt with the scientific side of the subject were entirely re-written and the discoveries of Linnæus, De Jussieu, Tournefort, Gærtner, Ray, and other distinguished writers were incorporated in the text. Each species, too, was treated fully, and in some sense, its history was given. Martyn revised the special technical work of Miller, but in the main left it unchanged.

On the completion of the work Martyn seems to have sent it forth with some trepidation. In his preface, not without a touch

of pathos, and marked by characteristic modesty, he says: "I am sensible that many will say, perhaps with a sneer, that the work is nothing but a mere compilation. The strictly original matter, indeed, bears so small a proportion to the whole, that the Editor is content it should pass under that humble title; but if the Gardeners' and Botanists' Dictionary were to be considered as nothing more than a *digest* of what was known on Gardening and Botany at the end of the 18th Century; or as a mass of information collected from the most scarce and valuable books, not accessible to the generality of readers, and written in languages little understood by practical men—the Editor flatters himself that it may well meet with the indulgence, if not the approbation of a candid public. He is conscious, at least to himself, that in the unwearied application of what talents he possesses, and the whole of that time which he could spare from the duties of his profession, during the last 20 years, to this laborious work, no attention or industry has been wanting on his part; and that he has strained every nerve to render it as complete in its kind as the nature of so extensive an undertaking will allow."

Though the form of the work did not lend itself to an arrangement of the matter exactly on the lines of a work on classification, and it could not therefore be a practical presentation of any particular system, the idea of the Linnean system was made as prominent as possible. In a letter to Pulteney under date July 26, 1786, Martyn wrote: "I am determined that the book shall contain in English *the marrow* of Linnæus's great works—the 'Genera' and 'Species Plantarum' and the 'Systema Vegetabilium.'" Seven years later he voices in another letter to his friend his regrets that he had not a freer hand in his treatment of the work: "I think so entirely with you on the subject of arrangement that if I were now to begin the work it should certainly appear in the order of Linnæus's system, with an alphabetical index, English and Latin; but I was to build on Miller's foundation. I almost hope that somebody will knock Miller and me on the head, hereafter, by such a publication."

Pulteney shared Martyn's regrets that the treatment he desired could not be adopted, for he was as ardent an adherent of Linnæus as the Professor himself. In 1796, writing to Martyn, he says: "I more and more lament that it could not have been thrown into a *systematic* form, so as to have been a regular Botanical work . . . but I hope at the end, to see a list of all the genera disposed in system for the use of those who may wish to study Botany

regularly by it, which this edition will much facilitate." Martyn replied: "I propose, among other matters, in the Introduction to have a complete *systematic* arrangement as you suggest."

However, the views of the booksellers prevailed and the name and plan of Miller still characterised the book.

This monumental work was expected by publishers and author to occupy the latter for nine years, and the remuneration agreed upon, a thousand guineas, was computed on that basis. It really occupied Martyn for twenty-two years, so that he cannot be said to have been overpaid for it. It appeared in four folio volumes in 1807. A second edition was projected, and partly brought out. Two volumes, carrying the work only as far as "Ebenus," were published in 1833, and are now in the library at Kew. There is a little uncertainty about the date, as the three parts of which the two volumes were composed bear the figures 1834. This edition was never completed.

Though he had the *Dictionary* in hand so many years, it did not occupy his attention to the exclusion of everything else. Devoted Linnean as he was, it is easy to understand how much he was impressed by the clearness and precision which his great master gave to description, and very early in his career he set before himself the determination to do as far as possible in English what Linnæus had done in Latin. Opportunity for the work only came with his retirement from the active duties of his Chair, but in 1786 he put forward his proposals in a new dictionary which he called the *Language of Botany*. In the preface to this book he explained his reasons for introducing new terms into the usage of description: "Many terms are indispensably necessary in the science of nature, where the objects that present themselves to our consideration are so numerous. The question, therefore, is not whether we shall have terms or no, but in what manner they should be constructed, so as to answer the great purpose of receiving and communicating knowledge most effectually? Now we have been long in possession of a precise and significant language invented by Linnæus, generally adopted by the learned of every country in Europe, and received in great part into the vernacular tongues of several. Can we do better, therefore, than to keep as close as possible to this, and to adopt the Linnean terms themselves, so far as the nature and structure of the English language will permit, and whenever we can do it without violating the laws of grammar and of common sense? . . . It remains, therefore, only to express my wish that the structure and genius of our

native language may be attended to, not only in the formation of the terms themselves, but in their terminations and plurals, their compounds and derivatives."

Another literary venture was started in 1792; this was the *Flora Rustica,* which proposed to give accurate figures and descriptions of such plants as were either useful or injurious in agriculture. It was but poorly supported, though issued periodically in separate numbers, each illustrated by coloured plates. What appeared of it was chiefly concerned with the grasses and with the weeds infesting pastures.

These literary labours occupied twenty years of Martyn's life. Till 1796 he continued to go up to Cambridge to give his annual course of lectures, but he gradually lost interest in them. After the first few years of his professorship, indeed, they appear to have been rather a matter of routine than of enjoyment. In 1776 he wrote to Pulteney: "My pupils are but few in number, and they are fewer still who give any attention to the science." At the close of his Cambridge work he says there was "so little zeal for the study in the University that it was scarcely possible to form a class." Doubtless much of this was due to the paralysing effect of the Linnean system, for under it speculation and research alike had perished and nothing but the dry bones of cataloguing plants remained. Possibly it was partly Martyn's own fault, for a later writer said: "I heard one individual say" (of Martyn's lectures) "that they were the dullest and heaviest things imaginable."

Though he ceased to lecture in 1796 he did not give up interest in botany at Cambridge. In 1804 he pressed Relhan to try to form a class during the spring, but even while he made the attempt he was in a very pessimistic frame of mind, for his letter contains the sentence "there does not seem to be Botanical spirit enough in the University to recompense you for the trouble that would attend it."

Dr. (afterwards Sir) J. E. Smith, the founder of the Linnean Society, offered to lecture in his stead in 1813, and arrangements were nearly completed for his doing so and succeeding Martyn as Walker Reader. But considerable opposition arose in the University, based upon Dr. Smith's religious views, and the movement came to nothing. Martyn endeavoured five years later to get Dr. Smith, who had been knighted in the interim, appointed as his deputy. Though the Vice-Chancellor favoured the plan and Sir James Smith issued a printed notice of the course of lectures he

proposed to give, the opposition was renewed, and was again successful. A very unhappy and acrimonious controversy ensued, which, however, did not involve the Professor.

In 1821 Martyn made another attempt to provide botanical teaching, endorsing a proposal made by Henslow to act as his deputy. The Walker Trustees again declined to consent.

In 1798 Martyn left London to reside at Pertenhall in Bedfordshire, and in 1804 became Rector there. He completed his work on the *Dictionary* in 1807, and with its publication practically said farewell to botanical science. He pursued the placid life of a country clergyman for nearly twenty years, keeping up his correspondence with his old friends and fellow-workers so long as they remained to him, and died in his ninetieth year in 1825.

Several distinctions came to him in his later years. In 1786 he was elected to the Fellowship of the Royal Society, and in 1788 to that of the Linnean Society, of which soon afterwards he became Vice-President. In 1793, through the influence of the Earl of Clarendon, a Regius Professorship of Botany was established at Cambridge with an endowment which, starting at £100 per annum, was afterwards doubled. This Chair was apparently founded for Martyn, and occupied by him in addition to the University Professorship, which he had then held without stipend for some thirty years. He was thus University and Regius Professor, Walker Reader, and Curator of the gardens. This Regius Professorship was subsequently held by his successor, Henslow, during whose life the University Chair was in abeyance. At Henslow's death the emoluments of the Regius Professorship were handed over to the University Chair and the Regius Professorship itself abolished.

In his later years, after his practical retirement from Cambridge, Martyn had little direct influence on the progress of botany. Never a strong man like his father, he had but little insight into things and no very great acuteness of judgment. Apart from the presentation of the work of others he did scarcely anything of value after the arrangement of his Cambridge flora. Much more the country clergyman with a taste for botany than an active worker, occupied in his study and not in the field, he stood aside for a great part of his life and let the stream pass by him without any effort to influence its course. He was a rather feeble son of a strong father ; a good administrator and a self-sacrificing friend ; a good teacher, but a poor lecturer, not much of an explorer, but a capable compiler who did good service in presenting anew the works of others. He had Ray's disposition, and was not

unlike him in the manner of his life, but he had no touch of Ray's genius.

It was, perhaps, unfortunate for him that his lot was cast just when it was. He began his studies with sound judgment, but the Linnean system drew him aside. He says: "About the year 1750 I was a pupil in the school of our great countryman, Ray. But the rich vein of knowledge, the profoundness and precision which I remarked everywhere in the Philosophia Botanica withdrew me from my first master, and I became a decided convert to that system of Botany which has since been generally received." In his attachment originally to Ray he took sides against the latter's great rival, Morison: "Whatever other merits Morison's great work might have, as a system or arrangement, it was worth nothing and was never followed. Whereas Ray's was the best arrangement till Linnæus arose." But his belief in Ray went further than this. He said again: "Foreigners have done great injustice to Ray. Even Linnæus and Pulteney have not done him complete justice. His distinctions are clear and logical, and he has preserved as many natural classes entire as Linnæus himself." But his conversion to Linnean ideas was complete and lifelong. He said: "The very dreams of so great a genius merit our attention," and scouted the idea of a return to a natural system. In 1767 in a letter to Pulteney he says: "The system-madness is epidemical. Gleditsch of Berlin and Crantz of Vienna have both come out with Natural ones, but I have not seen them. Adanson in his new volume of 'Familles des Plantes' has given us a sketch of about 60 new systems, altogether in my opinion not worth one farthing." All his life he opposed reform on natural lines, though towards its close it became evident that what he had held to be immovable rock was destined soon to pass away. It is not without a touch of pathos that he wrote in 1821 to Sir J. E. Smith: "I am not so rude a bigot as to think lightly of the Natural Orders, imperfect as is our present knowledge. . . . Had I been younger that very circumstance would have incited one to pursue so delectable a subject, and I hope you will continue to do it. I am only sometimes vexed when they would fain persuade me that the Natural System may *supersede* the artificial."

Martyn held the Chair of Botany at Cambridge for a longer period than any other professor; but when his whole career is considered it becomes evident that this was a matter for regret rather than congratulation. During his retirement at Pertenhall he slackened his grasp on the subject generally, as well as on his

university work. His advancing age led to suspension of his lectures, and when he did give any they were according to contemporary opinion dry, dull, and unattractive. His old enthusiasm vanished, and he became rather the country clergyman than the man of science. Still he held on to his Chair; true he made several efforts to get a deputy to carry out the work he no longer felt equal to, but he strangely failed to see the better way of making place for a successor by resignation.

Pulteney

As we have seen, Martyn during the greater part of his career stood, to a large extent, aside from the general stream of botanical thought. Not that he held aloof from other workers, for we find in his correspondence that he was well acquainted with Sir Joseph Banks, Sir J. E. Smith, and the other notable men of the day. He had, however, an intimate friendship for one naturalist in particular, with whom he carried on a correspondence for many years. It is strange to note that though exchanging letters with great frequency they did not meet until many years after their friendship was established.

This friend and kindred spirit was Dr. Richard Pulteney, F.R.S., to whose writings we owe much of our knowledge of the botanists of the sixteenth and seventeenth centuries. Like Martyn, Pulteney was an ardent Linnean, and in the opinion of many distinguished men of the time, contributed in very large measure to the introduction and establishment of the Linnean system in England.

Pulteney was born in 1730, and educated at the University of Edinburgh, where he graduated M.D. in 1764. He spent most of his subsequent life in medical practice at Blandford, where he resided from 1765 to his death in 1801.

He wrote two works which call for comment. One was a "General View of the writings of Linnæus," published in 1781. The other is the one by which he is better known, the "Historical and Biographical Sketches of the progress of Botany in England from its origin to the introduction of the Linnean System." It appeared in two volumes in 1790, bearing a dedication to Sir Joseph Banks. As its title-page suggests, it deals in the main with the lives of English botanists, and only incidentally presents a series of pictures of the development of the science. His industry and energy in compiling it were beyond all praise;

no worker in the field was forgotten, and justice was done to all. The book still stands as a monument to the many English workers, whose names would otherwise have passed from recollection.

In the preface Pulteney tells us that the work was originally intended as part of a larger scheme, which, however, he was unable to carry out. He says: "The attention I had given to English Botany in my younger days had prompted me at one time to plan a Flora of the plants of this kingdom, on an extensive scale; including besides the medical and œconomical history of each, a *Pinax*, in which it was my design to have distinguished, as far as I was able, the first discoverer of each species, both among foreign writers and those of our own kingdom; and to have arranged all their synonyms, at large, under each plant, in chronological order. To such a work the following sketches, in a somewhat more contracted form, were intended as an introduction. In the meantime, if more important avocations had not, the want of necessary assistance from books, would probably have stopped the progress of a plan of such extent. Although this purpose was relinquished yet as the materials were collected, and this part of the design was independent of the other, I flattered myself, that, having made some alterations and enlarged the whole under so total a want of any similar work, these anecdotes might afford information to young Botanists and possibly some amusement to those of more advanced knowledge in the science."

Though doubtless Pulteney would have written an admirable Pinax had his leisure permitted, it is not likely that it would have approached in value these sketches of which he speaks so modestly. The book is the only one of its kind, and has remained without imitator or successor to the present day.

CHAPTER XXVI

THE SUCCESSORS OF DILLENIUS AT OXFORD

So far as botany was concerned the centre of activity of university teaching passed after the death of Dillenius from Oxford to Cambridge. While the latter was the scene of the work of the two Martyns, who between them held the Chair of Botany for nearly a century, the study at Oxford fell into the leadership of much weaker hands. Dillenius was succeeded by Humphrey Sibthorp, who did little or nothing to develop the science at the University, or even to maintain it as his predecessor left it. He purchased the drawings and dried plants which Dillenius had accumulated, together with his library, but though he became thus in a way his literary executor, he did nothing to complete the *Pinax*, which had been Dillenius' most cherished project during his Oxford life. He retained the Professorship for thirty-six years, during which time he is said to have delivered only one lecture, and that not a successful one.

A better state of things followed the succession to the Chair of his son, John Sibthorp, who became Professor on his father's resignation in 1784. He was enthusiastic and persevering, impressed with the importance of botanical exploration in general, and of the possibilities which Oxford possessed for the development of the science in more branches than one.

He first showed his appreciation of things botanical by endeavouring to secure for Oxford the collections of Linnæus, which, on the death of his son, were disposed of by his family. Unfortunately for Sibthorp he was forestalled in the purchase by Dr. (afterwards Sir) J. E. Smith, who was some years later instrumental in founding the Linnean Society, to which body the collections now belong. The Oxford herbarium was already assuming considerable importance, and had Sibthorp succeeded its reputation would have been greatly enhanced.

Sibthorp not only recognised the importance of botanical exploration in the abstract, but he was ardently desirous of taking a personal share in it, and consequently soon after he was elected to the Sherardian Chair he undertook a prolonged tour in

Greece and the Archipelago, for the purpose of endeavouring to identify the plants recorded by Dioscorides. Probably as an Oxford man the classical side of his expedition appealed to him more than the strictly scientific, and not unnaturally, for the true bearing of the study of the world's flora hardly came to be recognised until the next century dawned, though the records of the Flinders expedition had been secured.

During his absence from Oxford he left Dr. George Shaw in charge of his department as Deputy Professor. He took with him the celebrated Austrian draughtsman, Ferdinand Bauer, a brother of the artist who was afterwards so intimately associated with Kew Gardens. When the results of the tour took the form of the *Flora Græca*, no little part of the success of the work was attributable to the excellence of Bauer's share in it.

The first tour occupied three years, and added considerably to Sibthorp's reputation. The services he had rendered to botany received recognition in very high quarters, and in 1793 King George III. granted a yearly sum of £200, half to augment the stipend of the Chair, and half towards the upkeep of the garden. Sibthorp was in the same year made a Regius Professor.

On his return from the East he undertook the preparation of a Flora of Oxfordshire. It seems strange that this had been delayed so long, for no less than four similar works had been prepared for Cambridgeshire. However, Sibthorp threw himself into the task with great energy, and collected no less than 1200 species himself within the limits of the County. He published his results in the form of the *Flora Oxfordiensis* in 1794, proving himself thereby to be a thoroughly critical botanist. His herbarium is still at Oxford.

While he was occupied in this task he was elected to the Fellowship of the Royal Society.

Having completed this local *Flora* he turned his eyes again to the East, and undertook another expedition to the same districts as before, in company with a botanical assistant. They travelled through Bithynia, the Troad, the Isles of Lemnos and Imbros, Attica, and Zante, and spent two months of the year 1795 in the Morea.

Unhappily, on his return to England, Sibthorp was seized with pulmonary disease, which terminated fatally in 1796. He bequeathed to the Oxford garden all his drawings, books of natural history, and collections.

His untimely death was a great loss to botany not only in

Oxford but in the greater world of the nation, in which he was one of the most conspicuous scientific figures of the period. The materials for the *Flora Græca* had been accumulated, but his death so soon after their completion had prevented their being put into anything like a condition suitable for publication. It was intended that the work should have appeared in ten folio volumes, each containing 100 of Bauer's plates; there was also to be a Prodromus, an 8vo volume without any plates. Though Sibthorp had collected 3000 species for the work he left nothing completed except Bauer's drawings and the plan of the Prodromus. After some years' delay the accumulated material was placed in the hands of Dr. (afterwards Sir) J. E. Smith, who was occupied with it for many years. Between 1806 and his death in 1828 Smith prepared six of the ten volumes for the press; a seventh appeared in 1830. After his death the work was taken up and completed by John Lindley, the last three volumes appearing between 1833 and 1840 under his editorship. The total cost of the production was £30,000. Owing to the high price which was charged for it only thirty copies were issued, and these were priced at 240 guineas each. Later still, in 1845, forty more copies were published by Bohn at £63 each, under the supervision of Daubeny, then Professor of Botany in Oxford. The original drawings of Bauer, numbering 966, were engraved for Smith's edition by James Sowerby.

Sibthorp made as far as he could a provision for the publication of this great work. He combined it, however, with another project which will always be associated with his name, and which was in some ways his greatest contribution to botanical progress. Impressed with the close relation of agriculture to the subject of his own Chair, and recognising the need of alliance between science and practice, he determined to found a Professorship of Rural Economy which should bear his name. In his will he left a freehold estate to the University for the double purpose of publishing with coloured plates his *Flora Græca*, and of endowing a Sibthorpian Professorship. He made it a condition that the latter Chair should be held by the Sherardian Professor, a condition which was observed till 1883.

During Sibthorp's tenure of the Professorship a commencement of the library at the Botanic Garden was made, one of the conservatories being altered to accommodate the books in 1795. It was an improvement greatly needed, for the great manuscript *Pinax*, on which Consul Sherard and Dillenius had spent so much

time and labour, had no permanent home. This great work occupied 446 packages, divided into 11 books and 116 sections. Unhappily it was never published, but it remains still one of the treasures of the library. The latter contains also the collections of Bobart, Sherard, John Sibthorp, Williams, and Daubeny. Many of Ferdinand Bauer's drawings, illustrative of the *Natural History of the Levant*, are also stored in it.

John Sibthorp was succeeded by Dr. George Williams of Corpus Christi College, who held the Chair till 1834. Under his administration we see a tendency to return to the easy-going policy of Sandys, Trowe, and the elder Sibthorp. He did little or nothing for the study, and under him the gardens became neglected, and the houses dilapidated and decayed. A contemporary account of the garden says that it then comprised five acres of land, and was exposed both in winter and summer to great danger of inundation. "The water frequently stands knee-deep above the plants; and as the lower parts of the garden cannot be sufficiently raised without an immense expense these portions are left quite uncultivated. The active gardener, who is a Scotchman named Baxter, devotes his attention chiefly to the Cryptogamia; partly from mortification at finding it impossible to make the garden such as he would wish. . . . Mr. Baxter also cultivates with zeal the English willows, having a living individual of almost every species, in a proper *Salicetum*. To the grasses, likewise, he gives much attention; and from the experience of several years he is enabled to decide that *Agrostis verticillata, vulgaris, decumbens, fasciculata* (Curt) and *stolonifera* are distinct species, which when subjected to the same culture for a great length of time, still continue to preserve their characteristic marks." The writer adds that there are between four and five thousand species of plants cultivated in "the wretched houses of this garden, though in fact there is only one stove, properly so called, and this is much too small." The plants growing in the open were arranged on the Linnean system, the native species being kept in separate beds from the exotics, and the annual, biennial, and perennial forms being kept severally together. Some of them were cultivated in beds, some in separate squares "without any view to the effect which this must naturally offer to the eye." Altogether the writer declares "the Oxford garden is inadequate to the purposes of botanical instruction in the present state of science."

Professor Williams awoke to some extent to the state of affairs

towards the end of his life, and made some efforts in the direction of their repair, leaving in his will a sum of £500 in Consols for that purpose. The lower areas which during rains were very liable to be flooded he had raised to a considerable height, and thus led the way to the changes which were effected by his successor, Daubeny. He was apparently not a very robust personality, and was troubled at times by the weakness of his sight which in some years prevented him from lecturing. But during his tenure of the Chair he seems to have been content that as far as botany was concerned Oxford should relapse into a state of slumber.

CHAPTER XXVII

THE WORK OF SIR JOSEPH BANKS

The aspect of botanical science, which is in the main directed towards taxonomy, was certainly obscured by the ascendency of the artificial system. The aspirations of Linnæus apparently failed to find an echo in the systematists of the period, who were fascinated by the simplicity of his actual proposals, and were content to try to force all vegetation into the limits of the artificial system. But while there was here great cause for regret it must not be forgotten that there were compensations. The precision and accuracy which he introduced into the art of describing plants had a very great effect upon systematic botany; indeed, the great geographical explorations which immediately followed would have been almost useless to botany had not some such system of describing plants been adopted. The period of the ascendency of the Linnean system was marked by a great extension of exploration of distant parts of the world, and the development of geographical knowledge of its tropical countries, with the necessary consequence of large additions to the recorded flora of the globe. This was an accompaniment of the enthusiasm for colonisation which marked the era, and was coincident with, and not dependent upon, the adoption of the Linnean proposals.

One of the foremost of the men of science who were connected with these advances was Sir Joseph Banks, for more than forty years the President of the Royal Society. Though a naturalist of considerable attainments he did little technical work himself to advance the science of botany, but indirectly no one of his age effected so much or exercised so great an influence. His accomplishments lay rather on the lines of Sir Hans Sloane and of Consul Sherard, but science would have been very materially poorer but for his career.

Sir Joseph Banks was born in London in 1743, and was educated at Harrow and subsequently at Eton. From a boy his tastes led him to the study of natural history, and a specially botanical impetus was given to him by the discovery during one of his vacations of a copy of Gerard's *Herball*, which was in the possession

of his mother. Leaving school with a considerable acquaintance with the subject, he entered Christ Church, Oxford, in 1760, just as the Linnean system was becoming generally accepted. At the time botany at Oxford was in a languishing condition; Dillenius was dead and his successor, the elder Sibthorp, did little for either the study or the advancement of the science. Banks took up the pursuit of the various branches of natural history with great avidity, and finding the position of botany hopeless, he persuaded the Professor to allow him to procure a competent teacher to take charge of the subject, on the understanding that his remuneration should come from the students. As a consequence he induced Lyons, the author a few years later of the Cambridge flora, to move for a time to Oxford and give lectures.

On the death of his father in 1761 he succeeded to his estates, not, however, entering into actual possession of them till 1764 when he came of age. The year before he went down from Oxford he took an honorary degree. His scientific reputation even then was considerable, and it was continuously advanced, till, in 1766, he was elected a Fellow of the Royal Society.

Banks was even at this early age strongly impressed with the spirit which led so many of his day to the colonisation of so many regions of the globe and which recognised the importance of intimate and cordial relations between the new territories and the mother country. This spirit may be traced in many episodes of his life. At the outset he evinced a certain restless energy prompting him to make a personal acquaintance with the new colonies and to a pursuit of further discoveries. He was especially interested in the botanical exploration of these lands, and he threw himself into this pursuit with great enthusiasm and self-denial. His first expedition was made in the summer of 1766, when in company with Lieutenant Phipps he visited Newfoundland with a view to studying its flora. Returning with many treasures he made the acquaintance of Solander, the friend of Linnæus, who had come to England in 1760, and was then assistant-librarian at the British Museum.

Just at that time the famous Captain Cook was engaged in the preparations for his voyage round the world in the *Endeavour*; Banks decided to accompany him, and he gathered round him several friends and companions for the voyage, among them being Solander. It was a most noteworthy expedition, both for the scientific results which were achieved and for the adventures and

hardships which the explorers encountered. The *Endeavour* left Plymouth on August 25, 1768, and was away from England till July 1771. The itinerary was the following: Arrival at Madeira, September 1768; Rio de Janeiro, November 13, 1768; Le Maire's Straits, January 7, 1769; Cape Horn, April 10, 1769; Tahiti, a little later; New Zealand, Australia, 1770; New Guinea, and by the Malay Archipelago to Batavia; thence to the Cape of Good Hope; St. Helena, 1771; and so to Plymouth.

Landing at Le Maire's Straits in January 1769, Banks nearly lost his life in an excursion into the interior; the explorers stayed six months in New Zealand, discovered and named Botany Bay in Australia, and were nearly wrecked on a coral reef off the coast of Queensland. Banks and Solander were attacked by malarial fever in the Malay Archipelago, and nearly lost their lives. The expedition, apart from its geographical results, did great service to botanical science in the accumulation of specimens of the greatest value and importance.

Nothing daunted by the hardships and dangers he had encountered, Banks proposed to accompany another expedition in the *Resolution* in the course of the year after his return, but unexpected difficulties arose and he abandoned the idea. In 1772, however, he went on an expedition to Iceland.

This was the last of his travels; he had accumulated a vast number of specimens including botanical treasures of the greatest value, most of them new to science. After they were arranged by assistants of great eminence, Banks made them freely accessible to all botanists without reference to nationality.

On his return from Iceland he settled down in London and devoted himself with great assiduity to scientific pursuits. His vast collections were housed at his residence in Soho Square, which became the gathering place of the scientific spirits of the time. His first assistant in the great task of arranging his collections was his friend Solander, who worked at them as far as his official duties allowed till his death in 1782. Jonas Dryander then took up the work and became Banks's librarian. Dying in 1810 he was succeeded by the most eminent of all, Robert Brown, who was ultimately Banks's legatee as far as the herbarium and library were concerned.

Banks's wealth and the scientific position to which he had attained made him the most conspicuous figure of the day in all that pertained to natural history. His house in Soho became the recognised centre of science, and his personal influence became

paramount among its devotees. In 1778 he succeeded Sir John Pringle as President of the Royal Society, and he held the position for forty-two years till his death in 1820.

Shortly after his election he was struck with the fact that in the work of the Society natural history played a part distinctly subordinate to physical and mathematical science, and he set himself to remedy this as far as his influence extended. A further feature of the Society which was far from meeting his approval was the fact that much of the executive power had fallen from the hands of the President into those of the Secretaries. In spite of much opposition in which a prominent part was taken by Dr. Horsley, afterwards Bishop of St. Asaph, Banks secured reform in both those directions and greatly advanced the usefulness of the Society thereby.

But the greatest service to botanical science in England which Banks was able to render was the assistance he gave to the development of Kew Gardens. With the establishment of this great institution we must deal in fuller detail later, but the part played by this great naturalist calls for notice here. Founded shortly before Banks's return to England they were principally managed till the death in 1762 of the Princess Augusta, mother of George III., by the Earl of Bute. From that date Banks became practically the Director of Kew, though he held no formal appointment. From his personal acquaintance with so many of the colonies he saw how mutually advantageous a close connection between them and the gardens would prove in the course of their development—what useful work could be done by a scientific investigation at home of the problems which the colonial flora presented, and how, thereby, the industries of the different settlements could be benefited. He was, consequently, anxious to develop and strengthen all such relations, exhibiting therein a sagacious statesmanship. The policy which he inaugurated has since always been a tradition of Kew; collectors have been sent out to all parts of the world to investigate its flora; exchanges have been effected, and experiments made upon the plants most suitable for cultivation under the conditions of soil and climate each colony presents, and a supply of young gardeners maintained and sent out when needed. Thus under Banks the gardens became the centre of botanical activity and influenced in a marked degree the development of exploration and experiment. From the collectors sent abroad rarities were obtained from all parts of the world, and huge collections were amassed which went to swell Banks's

herbarium, and to enrich the wealth of plant forms continually accumulating in the gardens.

Banks published but little himself, but he co-operated with Aiton in the preparation of the *Hortus Kewensis* which was brought out in 1783.

Among many other services which he rendered to botany should be mentioned the appointment of Francis Bauer as draughtsman to the gardens. Banks engaged him in 1790, two years after his arrival in England, and not only paid his salary during his own life, but arranged for its continuance after his death.

Banks was made a baronet in 1781, a K.C.B. in 1795, and a member of the Privy Council in 1797. Nor were his distinctions confined to his own country—he was made a Member of the National Institute of France in 1802.

While he lived he was certainly the most imposing figure of English science. He died at Isleworth in 1820, after suffering very greatly from gout. At his death he left his herbarium and library to Robert Brown with reversion to the British Museum, where both are now housed.

An unstinted eulogy was pronounced by Cuvier in the April after his death before the Académie Royale des Sciences. In its course he testified to the generous intervention of Banks on behalf of foreign naturalists which was evinced by his conduct during the war between France and England. Many botanical collections were captured by English vessels from their French possessors. Having been destined for De Jussieu they were sent back by Banks with explanations and apologies after their arrival in England.

Banks was not universally popular among the men of his time. His nature was extremely autocratic, and when he came to wield the power of the President of the Royal Society he let this be very apparent—indeed, he became almost despotic. The verdict of his contemporaries was, however, that with this overbearing attitude he was liberal and open in his behaviour to his acquaintance, and very persevering in his friendships. Those who knew him most intimately continued their connection with him and maintained their esteem and regard.

Banks may well be ranked with Sir Hans Sloane and Consul Sherard. He was no theoriser, but pre-eminently the collector, skilled in acquiring new plants from all over the world and in cultivating them. We may look upon him as a great accumulator of facts, but as possessing little of the spirit of the philosopher.

He accepted what he held to be good work on the authority of its author and made no attempt to criticise while accepting. This appears very clearly in his relations with Knight, to which we shall refer later.

Another feature of his personality was his ardent desire for the development of proper teaching in the universities. Hence his efforts to secure Lyons for Oxford and J. E. Smith as Martyn's deputy at Cambridge. To these we have already referred.

CHAPTER XXVIII

SIR J. E. SMITH AND HIS CONTEMPORARIES—THE LINNEAN SOCIETY

ANOTHER notable figure of the period with which we are now concerned was Sir James Edward Smith, to whose initiative the foundation of the Linnean Society of London was due.

Smith was born at Norwich in 1759. From his early youth he was attached to botany, though he did not begin its serious study till he had entered on his eighteenth year. In 1781 he entered the University of Edinburgh with a view to take up the profession of medicine. Hope was then Professor of Botany and he numbered Smith among his students. The latter made marked progress in the subject and was awarded a gold medal for his proficiency. In ~~1781~~ he left Edinburgh and came to London, where he quickly attracted the notice of Banks and secured his friendship. It is on record that he was breakfasting with him one morning in 1783, when Banks received from the mother of Linnæus, who had recently died, the offer of the whole of the Linnean collections. Sir Joseph did not feel at liberty to accept the offer, and strongly urged Smith to become the purchaser, the price asked being a thousand guineas. Smith immediately wrote to Upsala closing with the offer, and became the possessor of them in the course of the next year, lodging them in a house in Paradise Row, Chelsea. This seems to have been the turning point in his career, for abandoning medicine he took up the pursuit of botany, which he followed till his death.

The collections once arrived at Chelsea were examined and arranged as speedily as possible by their new possessor, who was aided in the task by Sir J. Banks and his then librarian, Dryander. They are now in the possession of the Linnean Society.

In 1785 Smith was elected to the Fellowship of the Royal Society. In June 1786 he took a continental tour. After graduating at Leyden, where he took a medical degree, he travelled through Holland, France, Italy, and Switzerland, making acquaintance with the leading men of science of the time. Returning to England in 1787 he took a house in Great Marlborough Street, London, and

soon afterwards the Linnean Society was founded. There was already in existence in London a small society which was called "The Natural History Society," but its aims were not ambitious and it had no publication attached to it. Together with several of his friends Smith projected an association on a broader basis, and with a more ambitious programme. The meeting to launch the new scheme was held on February 26, 1788, at the Marlborough Coffee House, Great Marlborough Street, where the Society, named after Linnæus, was constituted. Smith was elected President; Goodenough, afterwards Bishop of Carlisle, was the first Treasurer, and Thomas Marsham the first Secretary. The home of the new Society was soon transferred to the residence of the President, where two rooms were set apart for its use, and Dr. Smith gave lectures there on botany and zoology, the two subjects for the encouragement of which the society was founded. Its subsequent career was a very great success, and it has played no small part in the development of natural history in England. Smith retained the Presidency for forty years till his death in 1828, though he left London in 1796 and returned to his native city, Norwich. He used during the rest of his life to visit London for two months in each year, and was always present at the meetings during his residence in town.

The establishment of the Linnean Society, working on the same lines as the Royal Society, aided in bringing about almost a revolution in the matter of scientific literature. Publication took the form of memoirs read before one or other of these Societies, and issued by them in their *Journals* or *Transactions*. This became still more marked later, as scientific or "learned" societies multiplied. An author no longer made his pronouncement in the shape of a book or even a treatise.

In 1789 Smith republished under the title of *Reliquæ Rudbeckianæ* the wood blocks of plants that had been prepared by Rudbeck for his *Campi Elysii*, which had escaped the great fire at Upsala in 1702.

Smith's writings were voluminous, and many of them of the first importance. In 1790 he was associated with Sowerby in the production of the great work in thirty-six volumes which passes under the name of Sowerby's *English Botany*. Sowerby's wonderful skill in depicting plants found a happy outlet in the preparation of the drawings, and it was, no doubt, owing to the prominence of these that his name was associated with the work to the exclusion of Smith's, to whom the text and descriptions were due.

Indeed, it was not till the fourth volume appeared that his name appeared upon the title page. The work contained plates of all the British plants known except the Fungi. It was based on the system of Linnæus. Needless to say so exhaustive a work took many years to complete, the last volume not appearing till 1814.

According to the preface to the fourth volume, the work was originally projected by Sowerby. He formed the design of illustrating the plants of Great Britain by figures, his inimitable skill in delineating them being unimpeachable. He felt, however, that the figures should be accompanied by some accounts of the plants, and he asked Smith to join him in the work. The idea appealed strongly to the latter, as he felt it would afford him an opportunity of improving and fixing the botanical language of this country which, in his opinion, as in that of Martyn, lacked precision, especially when compared with the elegant Latin of Linnæus.

In the preface to the fourth volume Smith felt it necessary to acknowledge the share of the work which fell to him and accept full responsibility for the more strictly botanical part of it. He says: "I have therefore to answer for every word in this publication except the letter-press to plates 16, 17, and 18, which happened to be communicated by another friend of the Editor. . . . Some of my learned friends . . . advised that I should put my name to it by way of giving it consequence. . . . I chose rather that the work should make its way by any merit or utility that it might be found to possess, than be indebted to other performances for a name. Not that any pains were taken to conceal the real author; nor was I aware that the truth after a little time was not generally known; till a criticism appeared in the Gentleman's Magazine for February 1793; in answer to which, in that for April following, it became necessary to own the work as entirely mine, and the title page will in future obviate all doubt on the subject. . . . The English Botany will serve to illustrate the systematic Flora Britannica, which has been long projected and is now preparing."

At the outset neither Smith nor Sowerby seems to have been aware of the importance the book might, and did, attain. The faithfulness of the illustrations, repeated in subsequent editions, enabled it to maintain a popularity and usefulness far exceeding the later flora, so that even to-day it holds its place, while the *Flora Britannica* is almost forgotten.

In 1791 Smith's growing reputation led to his being chosen to arrange the Queen's herbarium and to his appointment to teach

botany and zoology to the young princesses at Frogmore. After this date he gave an annual lecture at the Royal Institution till 1825.

The next undertaking on which he was engaged was the preparation of Sibthorp's *Flora Græca* for publication with Ferdinand Bauer's illustrations. The *Prodromus* appeared in two volumes, one in 1806 and the other in 1813. Smith completed only six volumes of the *Flora*, the last appearing shortly before his death.

In 1807 he published the first edition of what was, perhaps, his most successful work, *Introduction to Physiological and Systematic Botany*. This was received with cordial welcome from his fellow-botanists, meeting with special encomium from Professor Thos. Martyn who was his close friend for many years.

Next year Smith began to contribute botanical articles to Rees' *Cyclopædia*, and continued to do so for many years, most of the botany it contains being from his pen.

In 1814 the Linnean Society, which had received a Royal Charter from George III. in 1802, invited the Prince Regent to become its Patron. On his acceptance of the position, Dr. Smith, the President, received the honour of knighthood.

The declining years and failing health of Professor Martyn had caused the study of botany at Cambridge to languish almost to the point of extinction. Banks, who had always felt a deep interest in the Cambridge school, instigated Smith to make an effort to resuscitate it, and accordingly in 1813 he applied to Martyn for his sanction to endeavour to improve matters by the delivery of a course of public lectures.

The Professor was not only willing but eager to accept the offer; indeed, he offered to resign the Walker Readership in his favour. Negotiations were at once set up with the Trustees; the Vice-Chancellor was favourable, but the other Trustees declined to assent. Their opposition seems to have been founded in the first instance by the view that in the condition of Martyn's health the selection of a new Professor was not likely to be long deferred, and that their assent might be taken to endorse a possible candidature. A second reason which certainly does not seem to indicate much liberality of thought was that Smith was not a member of the Church of England and was not either a member of the University.

The project fell through for the time, only to be revived in another form in 1818. Martyn then took the initiative and applied for Sir J. E. Smith to be allowed to lecture as his deputy. There was a precedent for this, as his own father had lectured before his

appointment to the Chair as deputy for Professor Bradley. In a letter dated March 14, 1818, he broached the subject to Smith in the following terms: "If you could . . . undertake to read a course next term, I should esteem it a great favour done to me personally, and I have no doubt of its being well received by the University. You are aware that you must have the sanction of the Vice-Chancellor, who, I am persuaded, will be ready to give the University an opportunity of profiting by your instructions; as he doubtless knows that you take the lead in the science of Botany in this country. As far as my power extends I am happy in giving you full authority to take such specimens of plants and flowers as you think requisite for your lectures, together with the use of the lecture-room at any time or times that may be convenient, always under the control of the Vice-Chancellor."

The Vice-Chancellor acceded to the request, and Smith issued a printed notice of his proposed course. However, eighteen tutors of Colleges, with the old illiberality shown before by the Trustees of the gardens, sent a written remonstrance to the Vice-Chancellor stating their disapprobation of their pupils attending the public lectures of "any person who is neither a member of the University, nor of the Church of England." Again bigotry carried the day, and though Sir James might well have lectured without paying regard to their attitude, he decided to give up the idea rather than enter upon a contest which might have been prolonged and would certainly have been disagreeable.

Naturally, the opposition left considerable soreness in his mind, and a controversy ensued, carried on by himself and the Rev. J. H. Monk, the Regius Professor of Greek, which was exceedingly acrimonious on both sides. It ended, of course, in Smith's metaphorically shaking the dust of Cambridge off his feet, and retiring from the scene.

In 1819 he was a candidate for the Chair of Botany in the University of Edinburgh, after the death of Professor Rutherford, but he was unsuccessful.

Sir J. E. Smith occupied the last seven years of his life with the preparation of what has been described as his best work, the *English Flora* to which he alluded in the preface to the *English Botany* already quoted. Two volumes appeared in 1824, a third in 1825, and the fourth in 1828, the year of the author's death. The *Compendium* in one volume appeared posthumously in 1829. The work was completed by a fifth volume which was published under the auspices of Sir W. J. Hooker and Rev. M. J. Berkeley

in the years 1833-36, the former being responsible for the Mosses and the latter for the Fungi.

Testimony to the value of Smith's works and the opinion of his contemporaries entertained of them is borne by a letter which Martyn wrote to him in 1821: "Your Grammar plainly speaks the hand of a master; concise, yet full; remarkable for its clearness and neatness. Small as it is in size it must have cost you some time and attention. I smile sometimes when I meet with the miserable incorrect compilations and imitations of your former work (the Introduction to Physiological and Systematic Botany). When your intended Flora makes its appearance, the British Botanist will find everything that he wants in these three works of yours."

Sir J. E. Smith's style was easy and fluent, his illustrations always happily chosen. The article on Ray's life which he contributed to Rees' *Cyclopædia* is a model of appreciatory writing, bringing the subject so graphically before the reader that the figure of the old botanist and divine seems to stand out full of charm and dignity, yet clothed with modesty and grace. His other writings also give evidence of extensive knowledge and elegant scholarship, both of which did much to popularise botany among his readers.

His library and collections were purchased by private subscription after his death, and were presented to the Linnean Society.

Withering

Mention should be made of the writings of another gifted amateur of this period, Withering, the author of a work that had considerable popularity, and was adopted by Smith and Sowerby as one of the authoritative pronouncements on English botany. Withering was born at Wellington in 1741, and educated at the University of Edinburgh, where he graduated as M.D. in 1766. He subsequently practised medicine at Stafford, where he was physician to the County Infirmary, and later at Birmingham. In the latter city he was eminently successful in his profession, and for thirteen years held the position of chief physician to the Birmingham General Hospital.

His botanical tastes were fostered by an acquaintance with Pulteney, whom he met during his student days at Edinburgh, and were developed during his residence at Stafford. He began collecting plants there for one of his lady patients, whom he subsequently married.

The fruit of this work was made evident soon after his removal to Birmingham, when he published in 1776 the book to which reference has been made, under the title of " Botanical Arrangement of all the vegetables naturally growing in Great Britain according to the system of the celebrated Linnæus, with an easy Introduction to the study of Botany."

While at Birmingham he became acquainted with Priestley and other leading chemists, and engaged in chemical research " to combat that monster Phlogiston."

He was elected a Fellow of the Royal Society in 1784, after which his work became concerned chiefly with chemistry and mineralogy, botany being put aside till 1786 when, after moving to Edgbaston Hall, he brought out a second edition of his *Botanical Arrangement.*

Withering became involved in trouble connected with the riots that followed the commemoration of the French Revolution, and had to fly from Edgbaston, breaking up finally his professional work at Birmingham. He devoted himself then to the preparation of a third volume of the *Botanical Arrangement,* dealing chiefly with the Fungi and other Cryptogams; he published it in 1792. His health beginning to fail he spent six months in Lisbon, hoping the change of climate would restore him, but being disappointed in this hope he returned to England, and took up his residence in the Isle of Wight, where he died in 1799.

Withering, though a strong Linnean, was not satisfied with the artificial system as its author left it. He modified it in his own book by merging the Gynandria, Monœcia, Diœcia, and Polygamia among the other classes. Still, he cannot be said to have made thereby any great impression on his fellow-workers or upon the progress of science. He was a correspondent of Afzelius, demonstrator of botany at Upsala, and of Thunberg, Linnæus's successor.

Ferdinand and Francis Bauer

Allusion has been made more than once to the artistic skill and the important botanical work of the brothers Bauer, who played such an active part in the scientific investigations of this period. The prominence that they assumed, however, demands more detailed examination.

They were the sons of an Austrian artist, and came to England as young men. Ferdinand achieved fame by his admirable work with Sibthorp, whom he accompanied on the expedition of which the *Flora Græca* was the result. The illustrations of plants

had been approached by no one since Ehret ; they were no less perfect in their artistic beauty than in their fidelity as botanical objects. While he was engaged on them at Oxford in 1788, his brother Francis came to England, though without any intention of taking up his residence here. He made the acquaintance of Sir Joseph Banks, who was then practically Director of Kew Gardens, and in 1790 he was induced to take up a semi-official position there as draughtsman to the gardens. Bauer was quite content to work there in that capacity, and accordingly remained in Kew during the rest of his life.

Ferdinand Bauer, after the completion of his work on the *Flora Græca*, was again disposed to travel. He possessed the greatest interest in exploration, and was a more ardent botanist than his brother. His next great tour was taken in association with Robert Brown, whom he accompanied in the voyage to Australia, and to Van Diemen's Land, an expedition which was under the leadership of Flinders. On this voyage he made a wonderful collection of drawings of great artistic excellence and scientific value.

Francis Bauer was afforded almost equal scope in the rare plants which Sir Joseph Banks was so keenly interested in cultivating at Kew, plants whose original homes were in all quarters of the globe, and numberless beautiful illustrations were the result, most of which are deposited in the British Museum, in conjunction with the treasures of Banks's library.

Among the other works which Francis Bauer executed were the wonderful drawings of the orchideous plants, in the publication of which he was associated with Lindley. The botanical publications of Robert Brown, which belong to a period a little later than the one now under consideration, owed a great deal to his illustrations.

Bauer was equally good at microscopical drawing. His delineations of microscopical anatomy were not confined to vegetable tissues. Perhaps, however, the most remarkable of them are the series now in the British Museum, illustrating the structure of wheat grains, their germination, and the development of the seedlings, together with the diseases to which they are subject. In the field of animal morphology he illustrated, by means of more than 120 plates, the investigations of Sir Everard Horne. He possessed, indeed, the rare combination of power of minute and careful observation with consummate skill in depicting the most difficult objects.

His Kew drawings already alluded to were published in 1796,

under the title "Delineations of Exotic Plants, cultivated in the Royal Gardens at Kew," with an interesting preface by the younger Aiton, in which he says that the Directors of the East India and the Sierra Leone Companies, as well as the Government of Jamaica, sent presents of plants to Kew. It was said of Bauer in connection with this publication: "In the delineation of plants he united the accuracy of a profound Naturalist with the skill of the accomplished artist. . . . In microscopical drawing he was altogether unrivalled, and science will be ever indebted for his elaborate illustration of animal and vegetable structures of which invaluable specimens are preserved in the British Museum and in the University of Göttingen." Niepce, the original discoverer of what is called the Daguerreotype, resided at Kew about the year 1827; in that year he was induced by Bauer, who was at that time Secretary of the Royal Society, to submit his discoveries to the Society, but as the method was a secret one his paper was not published.

Francis Bauer was made a Fellow of the Linnean Society in 1804 and his talent and attainments received recognition by his election to the Fellowship of the Royal Society in 1820. He died at Kew in 1840, having survived his brother Ferdinand fourteen years.

Dawson Turner

Among the less conspicuous figures of the botanical world at this time, place must be given to Dawson Turner, the father-in-law of Sir W. J. Hooker, who did good work among the Cryptogams. He was born at Great Yarmouth in 1775, and after studying at Pembroke College, Cambridge, became a banker in Norfolk. As an amateur naturalist he devoted himself with much ardour to botany, finally studying the Algæ with considerable success. In 1802 he published a synopsis of the British Fuci; in 1804 a tour in Ireland was followed by the appearance of a volume entitled *Muscologiæ Hibernicæ Spicilegium.* His chief publication was a general history of seaweeds, illustrated by coloured figures of all the species; it gave a full description of each in Latin and English. The work was commenced in 1808 and not completed till 1819, when it appeared in four volumes under the title: "Fuci, sive Plantarum Fucorum generi, a Botanicis ascriptum Icones, Descriptiones et Historia." It was illustrated by 258 plates. In collaboration with Bauer he commenced a similar work on Lichens of which only a small portion was completed at his death.

Dawson Turner was a zealous and indefatigable worker, and

perhaps the last of the botanists of the older Linnean school. He died in 1858 at an advanced age.

There were several other personages of this period whose names call for some recognition here, though their work in botany was not particularly conspicuous. Colin Milne, born at Aberdeen in 1743 and educated at Marischal College, was the author of a notable work, the *Botanical Dictionary*, which he published in 1770. He commenced to bring out a translation of the *Genera Plantarum* of Linnæus, but only completed the first part. In his later life he became a distinguished preacher in London and the south of England. He died in 1815.

Robson

Stephen Robson, born in 1741, was noteworthy as having published a British flora. He was of humble parentage, and was entirely self-taught. He spent most of his life at Darlington, whence he explored the country in the north of Yorkshire and the county of Durham. He published an earlier work on the rarer plants of the latter district, but his chief book was the *British Flora* of 1777, to which he prefixed "the principles of Botany." This work comes in point of time between the two editions of Hudson's *Flora Anglica*, and like them is arranged on the lines of the Linnean system. His nephew Edward was also an accomplished botanist, and a correspondent of Withering and J. E. Smith. He contributed various descriptions to the latter's *English Botany*.

Shaw

George Shaw, born in 1751, was educated at Magdalen College, Oxford, where he graduated as B.A. in 1769. He was subsequently ordained, but abandoning the Church for medicine he studied at Edinburgh for three years. Returning to Oxford he was appointed deputy botanical lecturer there under Professor John Sibthorp during the absence of the latter in Greece. When the Linnean Society was founded in 1788 he was one of the original members and was made a Vice-President. In 1789 the Royal Society elected him a Fellow. In his later years he became Keeper of the Natural History section of the British Museum. His writings were not extensive; they included the descriptions of plates 16, 17, and 18 of Sowerby's *English Botany*. He died in 1813.

Woodville

William Woodville, the author of a famous work on *Medical Botany*, was born in 1752, and after studying medicine at Edinburgh graduated as M.D. in 1775. In 1782 he moved to London and became physician to the small-pox hospital at St. Pancras. He was deeply interested in the medical side of the subject, and for its study he turned two acres of ground belonging to the hospital into a botanic garden which he kept up at his own expense. The *Medical Botany* was a description of all the plants in the catalogues of materia medica published by the Royal Colleges of Physicians of London and Edinburgh. The first volume was brought out in 1790, the second in 1792, a third in 1793, and a supplement in 1794. A subsequent edition was edited by Sir W. J. Hooker in 1832. Woodville died in 1805.

CHAPTER XXIX

BOTANIC GARDENS IN LONDON

Foundation of Kew Gardens

It was during the period which now concerns us that the supremacy of Chelsea as the leading botanic garden of the nation was challenged, and serious rivals were inaugurated, of which that at Kew was destined to become one of the leading scientific institutions of the world.

The foundation of Kew has been erroneously traced to the old garden of Turner, already mentioned. There seems, however, to be nothing authentic existing which justifies such a supposition. The facts afford nothing more than a coincidence.

There had been almost since the Restoration a botanic garden at Kew, which in private hands had attained considerable eminence. It was the property of the Capel family, whose head in the time of Charles II. was Sir Henry (afterwards Lord) Capel, a virtuoso who had gone far in the direction of horticulture. His seat was known as Kew House, and it became famous for its collection of botanical rarities. The garden is described in vol. xii. of the *Archæologia:* "Sir Henry Capel's garden at Kew has as curious greens and is as well kept as any about London. His two lentiscus trees, for which he paid forty pounds to Versprit, are said to be the best in England, not only of their kind, but of greens (evergreens). He has four white striped hollies, about four feet above their cases, kept round and regular, which cost him five pounds a tree this last year, and six laurustinuses he has, with large round equal heads, which are very flowery and make a fine show. His orange trees and other choice greens stand out in summer, in two walks about fourteen feet wide, enclosed with a timber frame about seven feet high, and set with silver firs hedgewise, which are as high as the frame, and this to secure them from wind and tempest, and sometimes from the scorching sun. His terrace-walk in the middle and grass on either side, with a hedge of rue on one side next a low wall, and a row of dwarf trees on the other shows very fine, and so do from thence his yew hedges, with trees of the same at equal distances, kept in pretty shapes with tonsure. His

flowers and fruits are of the best, for the advantage of which two parallel walks about fourteen feet high are now raised and almost furnished." In Evelyn's *Diary* under date of March 24, 1688, we read: "From thence we went to Kew to visit Sir Henry Capel's whose orangery and myrtetum are most beautiful and perfectly well kept. He was contriving very high palisadoes of reeds to shade his oranges during the summer, and painting these in oil."

Close by the grounds of Kew House, separated from them by only a bridle-path locally called Love Lane, lay Richmond Gardens, which were associated with a royal residence as far back as the reign of Edward I. In the reign of George II. they reverted, after having passed through the hands of various private owners, to Royalty again, becoming the property of Queen Caroline. They were laid out for her by Bridgeman "with an agreeable wildness and pleasing irregularity." After her death in 1737 they remained unchanged till the accession of George III. in 1760. Meantime, in 1730, Frederick, Prince of Wales, obtained a long lease of Kew House from the Capel family, and after his decease in 1751 his widow Princess Augusta spent her widowhood there. This princess may be regarded as the foundress of the Kew Gardens as we know them, for under her auspices the fusion of these two royal demesnes was inaugurated. Both had undergone considerable changes; the Prince of Wales had rearranged the pleasure grounds of Kew House and additional plantations had been constructed, while George III. obliterated all traces of Queen Caroline's occupation of the Richmond Gardens. "Of this famous Richmond Lodge, its magnificent gardens, the statuary, and the numerous and singular buildings with which the Queen of George II. had at such an extraordinary outlay enriched the place; the remains of the ancient monastery of Sheen, the large and embattled Gothic entrance, and the numerous houses still appertaining to the hamlet we have now not a vestige left." The entire site was converted into park land.

The fusion of the two demesnes was not carried out with undue haste. An Act of Parliament giving the King power to close the lane which separated them was passed in 1765, but it was not actually shut up till 1802.

Before the fusion the Princess Augusta inaugurated scientific developments in the garden of Kew House. In 1759 she engaged as one of the gardeners William Aiton, who had been trained under Philip Miller at Chelsea, and who became one of his most celebrated

pupils. By her instructions Aiton established a physic garden on the model of that at Chelsea, and so laid the foundation of the scientific institution of to-day. In 1763 we find Sir William Chambers writing in his *Plans of the Gardens* published in that year: "The Physic or Exotic Garden was not begun before the year 1760, so that it cannot possibly yet be in its perfection, but from the great botanical learning of him who is the principal manager (Lord Bute), and the assiduity with which all curious productions are collected from every part of the globe without any regard to expense, it may be concluded that in a few years this will be the amplest and best collection of curious plants in Europe."

Aiton was not at first the chief gardener, this post being held by Haverfield, who, however, in 1760 took charge of the Richmond gardens. When Haverfield died in 1784 Aiton became chief of the whole, conducting the management and development of both gardens.

The gardeners, however, were under the direction of the scientific adviser of the Princess, John Stuart, third Earl of Bute, to whom the first developments of the Kew scheme were due.

Lord Bute rendered considerable services to botany besides the share he took in the development of Kew. He had a fine botanical library, "very rich in books and dried specimens, as well as in volumes of plants . . . very many of the old Authors, and some very scarce ones." He published in nine volumes quarto, without plates or date of issue, "Botanical Tables containing the different Familys of British Plants distinguished by a few obvious parts of fructification, ranged in a synoptical method." The plates of this very rare book were the work of Johannes Sebastian Mueller, who was born at Nüremberg in 1715, and their issue fixes its date as not later than 1780, the year of his death in London. The first volume of Curtis's *Flora Londinensis* was dedicated to Lord Bute in 1777. Under Lord Bute's directions a great number of cedars of Lebanon, Weymouth pines, and rare trees were planted in the old arboretum at Kew in 1762. They were raised from seed at his seat at Whitton, and those that remain include some of the rarest trees in the gardens, in particular the great Turkey oak near the Temple of the Sun.

At the death of the Princess Augusta in 1772, the gardens came under the immediate care of George III. For some reason Lord Bute was not in favour of the King, and in consequence his connection with Kew was broken off. He was succeeded as scientific adviser by Sir Joseph Banks, who became thus practically Director

of the gardens, a position he held till the deaths of himself and of his royal patron in 1820. To his enlightened policy allusion has already been made.

Aiton being a pupil of Philip Miller, and the gardens being organised, or partly organised, on a scientific basis in 1760, it is not to be wondered at that they were originally arranged on the basis of the Linnean system. Aiton published, in 1783, a catalogue of the plants growing in the garden. In the preparation of the work, which he named *Hortus Kewensis*, he had the assistance of the Earl of Bute, Sir Joseph Banks, Solander, and Dryander. He was "universally known and esteemed in his own country, and his name and fame extended to different kingdoms and to every quarter of the globe." He died in 1793, and was succeeded by his son, William Townsend Aiton, who continued at the head of affairs till 1841.

The *Hortus Kewensis* of Aiton must not be confused with another work bearing the same name, which was published by Sir John Hill in 1758, and which was a catalogue of the plants under cultivation in the garden of the Princess of Wales before the fusion of the two royal demesnes. In this work, an 8vo of 458 pages, we find 3400 species enumerated under their Linnean names.

The work of Sir Joseph Banks at Kew was very memorable. Unlike his predecessor he had a definite policy involving the cultivation of close relations with the Colonies to the mutual benefit of them and of Kew, and in this he aimed at fostering their infant industries and developing their resources by applying to their problems the scientific information and technical skill which were associated with the gardens. Among the plants with which Banks enriched Kew in pursuance of this enlightened policy were *Hydrangea hortensis*, *Pæonia mouton*, and *Fuchsia magellanica*. It was his custom to retain rare plants at Kew for a year after they had flowered, and then distribute them to learned societies and to eminent men. In 1784 he introduced *Nelumbium speciosum*, the well-known sacred bean, and *Strelitzia regina*, named after Queen Caroline. One of his most cherished schemes was to found a herbarium and library at Kew, but the scheme was temporarily abandoned. Banks's own herbarium and library passed ultimately to the British Museum, and became the foundation of its botanical department.

Under Banks's auspices Francis Bauer, the celebrated botanical draughtsman, was employed at Kew from 1790 onwards, and he left a magnificent collection of drawings. Banks considered a

national botanical institution incomplete without a draughtsman, and consequently not only arranged for him to join the scientific staff, but provided for the payment of his salary so long as he should live.

Another departure, a direct outcome of the policy he set himself to pursue, was inaugurated while he was in control of affairs. This was the practice of sending out collectors to distant countries to furnish the gardens with exotic rarities. It began in 1772 when Sir John Pringle, formerly President of the Royal Society, obtained permission from the King for one of the under-gardeners at Kew, Francis Masson, to reside for some time at the Cape of Good Hope, with the view of collecting seeds and living plants for the gardens at Kew. For this purpose Masson was allowed £300 a year. During the three years of his residence at the Cape (1774-76) he sent home 400 species of living plants, which included many Cape Heaths and Pelargoniums. A plant introduced by him in 1775, *Encephalartos longifolius*, still exists in the palm house. He made a second voyage to the Cape followed by a stay of longer duration. Between 1786 and 1795 he sent numerous plants to Kew, and in 1796 he published a folio volume of coloured figures and descriptions of the *Stapeliæ* of South Africa; *Cineraria cruenta*, the parent of our garden cinerarias, and the popular Cape bulb, *Eucomis punctata*, were introduced into England by him at Kew.

Another Kew gardener, David Nelson, was assistant botanist during Cook's third voyage, 1776-79. L'Heritier founded the famous genus *Eucalyptus* on *E. obliqua*, first found by Nelson in Van Diemen's Land, and introduced into cultivation by Captain Furneaux in 1774. Christopher Smith took the place of Nelson in 1791, and brought home in 1793 a large collection of living plants from the West Indies. He was afterwards appointed botanist to the East India Company, and prepared a large collection of plants at Calcutta for Kew, which were brought home by Peter Good in 1796. In 1797 he visited the Moluccas, whence he brought an accumulation of dried specimens. James Wiles accompanied Smith on Bligh's voyage. In 1793 he was given the charge of the very fine botanical garden formed by Hinton East at Gordon Town, Jamaica, a charge he held till 1805. Archibald Menzies, botanist and surgeon, accompanied Vancouver in his voyage of survey between 1791 and 1795. He made a rich collection of herbarium specimens and seeds, transmitting also to Kew cones of Banksia and other Proteaceæ. Anthony Pantaleon Hone, a

Pole, was also employed by Kew at the instance of Banks, to collect plants in India. Other explorers who did good service of this kind were Good, through whom Kew obtained its fine collection of Proteaceæ, and who was the friend and companion of Robert Brown; Caley, who made collections in New South Wales; Ker, who, after visiting Java and the Philippines, became superintendent of the Royal Gardens, Ceylon; Cunningham, who visited Brazil, South Africa, Australia, and New Zealand, ultimately becoming superintendent of the Sydney Botanic Garden; and Lockhart, later superintendent of the gardens, Trinidad. Small wonder that with such contributors the collections at Kew soon became of world-wide fame.

Among Banks's conceptions of Kew as the centre for scientific intercourse between the mother country and the colonies, the foundation of a library and a herbarium held an important place. So many plants were coming in from abroad, and so great was the accumulation of specimens, that he saw some definite provision for their housing was imperative. He was the custodian of so many collections that had come in that the absence of a national herbarium impressed him more than anything else. The need became more and more pressing as time went on, and in 1818 he took some definite steps. Near the gardens, almost indeed within their bounds, stood Hunter House, which he wished to appropriate for the purpose, and at his instigation the advisers of the Crown purchased it. Steps were initiated to fit it to serve as both herbarium and library, but, unfortunately, Banks's death in 1820 led to its being devoted to other purposes. In 1830 it was given up for a residence to the King of Hanover, and was occupied by him till his death in 1851.

In 1852 part of it was put at the disposal of Sir W. J. Hooker to receive his herbarium, and in the next year the first step to carrying out Banks's plans was taken. As we shall see, the collection of Dr. Bromfield was then housed there, having been presented to Kew, and forming the nucleus of the present herbarium. Hunter House continued to contain Sir W. J. Hooker's plants till after his death in 1865, when the government bought them. In the meantime the national collection had been greatly enriched by the generosity of various donors. To the development of the herbarium we shall return later. It can only be noted here that the first conception of it was due to Banks. To the fact that he did not succeed in founding it during his life is ultimately due the existence of two national herbaria, for his own collections

and those sent in from the colonies during his life ultimately formed the nucleus of the botanical department at the British Museum, in accordance with his will. There is little doubt they would have been sent to Kew had the herbarium been constituted as Banks hoped.

Besides the works to which reference has already been made, several publications of importance emanated from Kew during the years now under consideration. L'Heritier de Boutelle, a French botanist of some reputation, came to England in 1786 and made a study of the Kew collections, which he subsequently utilised in his "Sertum Anglicum, seu plantæ rariores, quæ in hortis juxta Londinum imprimis in horto regio Kewensis excolantur." The plates, of which there were thirty-four, were the work of Redoute, the celebrated French botanical artist. L'Heritier speaks in warm terms of the resources of the gardens, and describes many of Masson's introductions.

The younger Aiton, who succeeded his father in the superintendence of the gardens, published in 1813, in five volumes, a second edition of the *Hortus Kewensis* of his father, and in the next year he issued, for the use of practical gardeners, a catalogue or epitome of the species contained in the five volumes, a task in which he had throughout the assistance of Dryander, who was then Banks's librarian.

In 1822 Aiton commenced a new and important undertaking by having drawings made of such plants in the garden as had not previously been figured. The first artist he engaged was Thomas Duncanson, a young gardener from the Royal Botanic Garden at Edinburgh, who was succeeded in 1826 by George Bond, then employed on the staff at Kew.

During the early years of their establishment Kew Gardens were not open to the public. In 1819 they were open only every Monday during the summer. It was not till many years later that they became generally accessible.

CHAPTER XXX

BOTANIC GARDENS IN LONDON—*continued*

Chelsea Physic Garden

WE have seen that Chelsea exerted considerable influence on the adoption of the Linnean system in England. Philip Miller, who had in his early days been a strong adherent of Ray's classification, became in later life a devoted supporter of Linnæus's proposals. He partially adopted them as already mentioned in the 1759 edition of his *Gardener's Dictionary*, and more completely in that of 1768. The completeness of his conversion is seen in the "Short Introduction to Knowledge of the Science of Botany, explaining the terms of Art made use of in the Linnean System," published in 1760.

Hudson

There was another Chelsea personality of this period who rendered substantial aid to the work of his contemporaries in this direction. This was William Hudson, who afterwards became director of the garden, and who wrote what was probably the first important English book that was arranged on the Linnean system, if we except the *Flora Botannica* of Hill, which met with condemnation rather than appreciation.

Hudson was born at Kendal in 1732, and when still a young man settled down as an apothecary in London. As a member of the Apothecaries' Company he took great interest in the Chelsea Garden and served on its committee. He embraced the Linnean system and became one of its most strenuous advocates. In 1762 he published his great work, *Flora Anglica*, which was arranged according to its proposals. In the preface Hudson acknowledges that he was very much indebted to Ray's *Synopsis*, the book which his own was very soon to supersede, and he puts on record his appreciation of what Ray had done, at the same time letting it be seen that he held his day to be past, and his reputation about to bow before the (to him) much greater one of the new genius, to whom he bears a very fulsome testimony.

The *Flora Anglica* soon came to be considered the standard English flora. Ray's *Synopsis* had held the position for seventy-two years, but was at the moment out of print, and while the movement of opinion in botany held the direction it had then taken, it was very unlikely that a new edition would appear. Hudson's book had much to recommend it; the descriptions of plants were clear and concise, the localities very carefully given, and the medicinal properties of the plants and their application to the needs of the healing art were set out as completely as possible, while the various synonyms by which they had been known were given with much fullness of detail. The Cryptogams were very freely treated, more than half the second volume of the work being devoted to them. Hudson specially mentions in the preface the care and attention this section of the work had received.

This book brought Hudson into the front rank among the English botanists. His reputation had been growing previously, so much so that he had been made a Fellow of the Royal Society in 1761. He became acquainted with Linnæus, Haller, and other eminent naturalists abroad, and was enabled to take a more conspicuous share in the management of the Apothecaries' Company. He was made Director of the garden and botanical Demonstrator in 1765 and retained these appointments till 1771. With his resignation his botanical career seems to have practically closed, though he became a Fellow of the Linnean Society in 1791. He died in 1793, and left his herbarium to the Apothecaries' Society.

Hudson's claim to distinction rests upon the work he did in connection with the adoption in England of Linnæus's proposals. While Martyn and Hope were their outspoken advocates, Hudson made their acceptance possible by the general botanical world by preparing and arranging the English flora upon the new basis, and by introducing the Linnean binomial nomenclature.

The years 1770 and 1771 saw great changes at Chelsea. For several years pecuniary difficulties had been more and more acutely pressing; Miller being most put to it for money for the current expenses of the garden and for his own salary. In 1770 he found that the difficulties of the position and the friction they caused between himself and the garden committee had become insuperable, and he accordingly resigned. A small retiring pension of £50 a year was offered to and accepted by him, but he only lived a year to enjoy it. The resignation of Hudson was, as we have seen, accepted in 1771, so that with but little interval the posts of Director and Curator passed into fresh hands.

Curtis

Hudson was succeeded by another very noted botanist, Wm. Curtis, after a two years' interval, during which the post of Director was made an honorary one, and was held by Mr. Alchorne. Miller was succeeded by one of his old pupils, William Forsyth.

During the new management, affairs seem to have gone on more smoothly, though the old trouble about pecuniary matters was never very long in abeyance. A strange step was taken in 1774 to mitigate the strain, the gardener being given permission to sell for his own benefit surplus specimens of the plants growing in the garden, a process hardly likely in the long-run to prove satisfactory to either party.

Curtis was elected to the Directorship in December 1773, and his appointment was made the occasion of drawing up the new code of regulations which has already been quoted. He was born at Alton in Hampshire in 1746, and was trained there as an apothecary. At the end of his apprenticeship he moved to London and set up in business in Gracechurch Street as an apothecary and medical practitioner. After his appointment at Chelsea he devoted considerable time to lecturing on botany in addition to discharging the other duties of the Director. For the benefit of his pupils he cultivated a large number of the indigenous plants of the country in three gardens of his own, Chelsea not supplying adequate space for the purpose.

In 1777 he commenced the publication, under the title of *Flora Londinensis*, of what he intended to be a list of all the plants growing within 10 miles of London. It was confined, however, to six fasciculi of seventy-two plants each, owing to the limited circulation it secured, the sale not exceeding 300 copies. The six fasciculi which appeared were in the highest degree creditable to the author and to the draughtsmen who assisted him, the work of the latter being especially good. But like so many other enterprises in which science and art have been united, the apathy of the purchasing public involved a suspension of the project long before it was completed.

Another enterprise followed, which did really hit the public taste. This was the *Botanical Magazine*, which Curtis launched about 1787. It speedily reached a circulation of 3000, and has been continued to the present day, subsequently numbering amongst its editors Dr. Sims, Sir W. J. Hooker, and Sir J. D. Hooker. It was a very remarkable work, dealing rather with

horticulture than botany. Curtis spoke of its aim in the preface in the following terms: "The present periodical publication owes its commencement to the repeated solicitations of several Ladies and Gentlemen who were frequently lamenting the want of a work which might enable them not only to acquire a systematic knowledge of the Foreign Plants growing in their gardens, but which might at the same time afford them the best information respecting their culture—in fact, a work in which Botany and Gardening . . . or the labour of Linnæus and Miller might happily be combined. In compliance with their wishes, he has endeavoured to present them with the united information of both authors, and to illustrate each by a set of new figures drawn always from the living plant, and coloured as near to nature as the imperfection of colouring will admit."

Though not a voluminous writer, Curtis contributed many papers to scientific journals, particularly the *Transactions* of the Linnean Society. He was a well-known figure in botanical circles, and a friend of the leaders of the scientific thought of the time. Unfortunately, his life was cut short in 1799 at the comparatively early age of fifty-two.

Thomas Wheeler

Curtis only held the Directorship of Chelsea Garden till 1777, and after a brief interval he was succeeded early in 1778 by another very prominent figure in the botanical world, Mr. Thomas Wheeler, who remained at the head of affairs for forty-two years. He was born in 1754, and after receiving his education at St. Paul's School was apprenticed to an apothecary in St. James's Street. He had but little liking for his calling, and at the expiration of his indentures he entered St. Thomas's Hospital to pursue the study of medicine. He was always attached to botanical pursuits and was much encouraged therein by Hudson, then Director of Chelsea. He was only twenty-four years of age when he succeeded Curtis. His career at Chelsea was a very prolonged, but not a very distinguished one, though he attained great celebrity as a teacher. In 1784 he lost the co-operation of Forsyth, who became the head of the staff in his Majesty's garden at Kensington. During his term of service at Chelsea Forsyth had become distinguished as a specialist in the cultivation of fruit and forest trees, giving his attention especially to their pathology, on which he published a book in 1791. He followed it by a treatise on their

management in 1802. He was succeeded at Chelsea by Fairbairn who continued to assist Wheeler nearly all the rest of the latter's Directorship.

Wheeler did not restrict his activities to the garden; combining the practice of the apothecary with the study of medicine, he became apothecary to Christ's Hospital in 1800 and to St. Bartholomew's in 1806. He took, also, an active share in the administration of the Apothecaries' Company, of which he ultimately became Master in 1822. He was also a member of the first county examiners appointed by the society under the Act of 1815. From 1790 to 1796 he practised as an apothecary in Newgate Street.

Though no writer, he held a high position among the botanists of the time. It was his special delight to take part in the Society's herborisings, which were for many years under his direction, and which he made famous throughout England. After he had ceased to be connected with Chelsea he continued to attend these gatherings, at which he was certainly the most prominent figure. His minute knowledge of the flora of the London region and his authoritative pronouncement upon all questions of species made his co-operation of the highest value. He was—like the other Chelsea authorities of the time—an enthusiastic supporter of the Linnean system, though during his later years there were not wanting signs of its approaching supersession by the natural system whose resuscitation and development under the auspices of the French school were continually becoming more and more evident after De Jussieu's pronouncement in 1789. Wheeler was a bitter opponent of De Jussieu. He retired from his offices at St. Bartholomew's Hospital and Chelsea Garden in 1820 at the age of sixty-six. He was succeeded at Chelsea by his third son, James L. Wheeler, under whose direction the natural system began to make headway. The old veteran lived to the age of ninety-three, dying at the house of his eldest son in 1847.

The gardener, Fairbairn, who had succeeded Forsyth, died in 1814, a few years before Wheeler's resignation. He had been in office for upwards of thirty years, and in his later days had allowed things to suffer from the neglect entailed by his great age and his consequent infirmities. He was succeeded by William Anderson whose enterprise combined with energy soon put matters on a more satisfactory footing. The end of the period with which this chapter is concerned, found Chelsea still the centre of much activity, and playing its part in the progress of botany.

CHAPTER XXXI

CONTEMPORARY BOTANY IN SCOTLAND AND IRELAND

Hope

Among the factors that conduced to the acceptance of the Linnean system, we have already noticed that the influence of the leading teachers of the time ranked high. The part played by Martyn at Cambridge was ably sustained in Edinburgh by the activities of Hope, who succeeded Alston as King's Botanist and University Professor of Botany there in 1761.

John Hope was born in 1725 at Edinburgh and was educated at Dalkeith, going later to the University of Edinburgh, and to certain medical schools abroad. He graduated, however, from the University of Glasgow in 1750, joined the College of Physicians and practised his profession there.

He began to study botany under De Jussieu in Paris during his residence abroad, and attained a creditable reputation for his knowledge of the science, so that he was chosen in 1761 to succeed Alston, first as King's Botanist and very shortly afterwards as University Professor of Botany and Materia Medica. With the former post was associated the care of the Royal Garden at Holyrood. During the early years of his professorship Hope lectured in summer on botany, and in winter on Materia Medica, but in 1768 he resigned the charge of the latter subject. Certain changes took place involving a good deal of readjustment, and Hope was given a new commission as Regius Professor of Botany and Medicine, Materia Medica being constituted a separate Chair in consequence.

Hope was much in advance of Alston in his attitude to science, being possessed of the conviction that research and experiment were destined to play a considerable part in the development of botany. At first sight he may seem to fall behind his predecessor in becoming an ardent adherent of the Linnean system. But this is more in appearance than reality, for we have seen that Alston's opposition was based on the views he held on the sexuality of plants rather than on the application of the numbers of the so-called sexual parts of the flower to the delimitation of classes. It does, however, seem rather strange to notice that a man of some

originality of thought, holding the views he held on research, should accept the Linnean system apparently without much consideration. He had, moreover, begun his botanical studies under De Jussieu, the man who did so much to start the revival of the natural system, and whose own proposals tended so greatly to bring about the overthrow of the Linnean system. Yet he proved an ardent supporter of the latter and his influence secured its adoption in Scotland. He was hardly so thorough-going as Martyn, for he had leanings to the views of De Jussieu and the natural system, but at any rate on his first assuming the responsibilities of the professoriate, he threw himself with much energy into the project for the adoption of the artificial system, possibly led thereto by the very chaotic state of the alternative schemes at the time. He was, however, apart from the latter consideration, no doubt actuated by his personal regard and friendship for Linnæus himself. Holding these views Hope brought about a very marked change in the university teaching from the anti-Linnean attitude of his predecessor.

Through Hope's exertions the site of the botanic garden at Edinburgh was again changed. The existing gardens were inconveniently situated, and separated from one another ; the soil was in places swampy and unsuitable, and the city was continually encroaching on its site. The plants, too, were not satisfactorily arranged, for the gardens had been mainly medical in aim, and they had been arranged for teaching. In 1776 Hope obtained possession of a site more on the outskirts of the city, lying to the west of Leith Walk, where there was freedom from the smoke of Edinburgh and where there was considerable variety of soil and exposure. Securing this more favourable location, he was able to combine in one collection the plants of both the Holyrood and the town gardens. A still more satisfactory feature was the fact that he was able to secure for the first time that the maintenance of the garden should receive some support from the Government, who granted it a permanent endowment.

When he came to arrange the garden, he did so on the plan of the Linnean classes, a change from the old gardens which was highly appreciated by Linnæus himself. His attachment to the great Swede, of which he had given so many proofs, was further demonstrated at the death of the latter, when Hope at his own expense erected a monument to him in the garden with the inscription : "Linnæo posuit Johannes Hope."

Hope planned to associate the natural system with that of

Linnæus, but the difficulties were too great and the work was never completed. His efforts to furnish the garden were enthusiastically supported by many of his old pupils both at home and abroad, and with their aid he accumulated a large number of very rare plants, so that it became for the time being the most comprehensive collection in Great Britain.

Hope cherished a design to publish a *Flora Scotica*, intending to avail himself of the efforts of his pupils whom he encouraged to investigate the local floras. He was, himself, a field botanist, and, like Ray before him, he was in touch with many amateurs of considerable attainments who were in a position to render assistance to the scheme. It came to nothing, however, and no *Flora Scotica* appeared till the work of Lightfoot, who was a friend and correspondent of Hope. To this volume we shall allude in its proper place. But Hope's botanical reputation does not rest entirely upon his work in taxonomy. He was far in advance of his Scottish contemporaries in his acquaintance with, and attachment to, the study of physiological processes. Hales had excited the spirit of inquiry into these problems, and had made considerable progress, as we have seen. He had, indeed, opened the way to more definite research, and had brought many questions to the point for the first time. To some extent his mantle had fallen upon Hope, who manifested the possession of a similar desire to ascertain the truth by means of careful experiment. The problems which engaged his attention were, to some extent, those of the workers of the 17th century; he investigated practically the question of the ascent of the sap with its collateral points, the root pressure, and the general circulation. In these matters he held sounder opinions than the older writers, being an opponent of the views current among them. But he took great interest in the difficult questions of heliotropic and geotropic curvature, of the positions assumed by the different members of the plant in their development, and their adult condition, and of the general phenomena of internal and external growth. He left in the archives of the University of Edinburgh a collection of drawings of exceptional merit, together with a manuscript volume of his lectures. The drawings include some studies of the nyctitropic movements of several plants, one said by Sir Francis Darwin to be "probably the earliest existing illustration of a sleeping *Desmodium*."[1] In devising some of his experiments he showed even greater ingenuity than Hales.

[1] *Notes from the Royal Botanic Garden, Edinburgh*, No. xx., 1909.

Hope's distinction was recognised in England by his election to the Fellowship of the Royal Society. He died in 1786, and was succeeded in his chairs by Rutherford, who continued to occupy them till his death in 1819, but made no contribution to the advancement of the science.

Lightfoot

Allusion has been made to a distinguished contemporary of Hope — Lightfoot, an Englishman by birth, who published a *Flora Scotica* in 1777. He was born in 1735 and educated at Gloucester, subsequently graduating from Pembroke College, Oxford, in 1756. He proceeded to the M.A. degree in 1765. Like so many of the botanists whom we have noticed, he was ordained and held several preferments in the Church of England. The work on which he based the *Flora* was chiefly done during 1772, the whole of which year he passed in exploring the botany of Scotland. He was not without assistance in his task, being helped in his survey by many local botanists and having the co-operation of Hope in Scotland, as well as of Solander, Banks, and Sibthorp the younger, in England. By the help of the last named, he had access to Dillenius's Cryptogamic herbarium at Oxford. The *Flora Scotica* contained descriptions of 119 Mosses, 103 Lichens, 81 Algæ, and 87 Fungi, together with 840 flowering plants, some of which, however, were naturalised forms.

Don

Another name which calls for notice is that of George Don, about whose work much criticism, some of it aggressively acrimonious, has centred. It was at one time the fashion to decry his statements and repudiate his discoveries ; a fashion due largely to Arnott and the Glasgow school. More recent workers, notably Druce, have joined issue with his critics, and after examination of the plants he left, have affirmed his reliability.

Don was born at Muirhead in 1764 of humble parentage. He had a poor education and was at an early age apprenticed to a clockmaker in Dunblane. During his residence there he developed a great liking for botany, and became an indefatigable explorer and collector of plants. When his apprenticeship was over he removed to Glasgow, where he regularly devoted two days each week to botanising in the neighbourhood. From Glasgow he moved to Dupplin, where he seized his opportunities of exploring

the Ochills and the outlying spurs of the Grampians. In 1790 he settled at Forfar, where he established a kind of botanic garden and a nursery for trees. In his leisure hours he worked at the exploration of the Highlands and discovered the beautiful district of Clova. Many of the specimens he found were sent to J. E. Smith, and were subsequently figured in the great work of Sowerby.

In 1792 Smith recommended Don to the notice of Rutherford, Hope's successor in the Edinburgh Professorship, and he appointed him Superintendent of the botanic garden. He only held the post three years, however; but he made use of the opportunity to attend all the medical classes, and on his return to Forfar he went into practice as a doctor. In 1803 he was made an Associate of the Linnean Society.

The results of his painstaking explorations took shape in the publication of a *Herbarium Britannicum* which he commenced in 1804; he proposed to bring out four fasciculi every year till it should be completed, each to contain twenty-five plates. In his preface he gives a summary of the qualification he felt he possessed for such a work: "Since I began my botanical excursions into the Highlands of Scotland in the year 1779 I am confident (and I hope I may mention it without the imputation of vanity) that I have traversed more of the Caledonian Alps than any other botanist has ever done. I have repeatedly ranged over the great mountains of Angusshire, which surround the great district of Clova, where no one on a similar pursuit has ever preceded me. I have also searched the vast range of mountains which stretch about sixty miles through the district of Knoydart in Inverness-shire, a region which had never before nor has since been examined by a botanical eye. I am the only botanist, too, who has explored the lofty mountains of Cairngorm and the great hills of the neighbourhood."

His botanical work led him to neglect his practice, and his financial affairs fell into great confusion which culminated in his having to compromise with his creditors in 1812. He never got over this disaster, which gave a great shock to his Scottish integrity and independence. He lingered on till January 1814, when he died in extreme poverty. His sons, George and David Don, inherited his botanical talent, and followed botany as a profession. The younger ultimately became Librarian to the Linnean Society.

The more recent investigations into Don's work have led to the opinion now held by most botanists that the strictures passed upon him and the disbelief entertained in some high quarters as

to the accuracy of his records were altogether undeserved. Of the many records he left, only about a score have been found untrustworthy; the plants not having been found again in the localities he gave. There is much reason to think he found the plants, as he said he did, but that he did not attach so much importance to their localities as to record the latter with the precision that is demanded to-day. In his time such precision was not very closely observed, the plant's existence being the main thing to which importance was attached, and its locality being thrust into a secondary place; the geographical delimitation of the country, moreover, was often vague and uncertain. There are many other excuses that may be urged for a poor overworked botanist; his work was done in poverty and under heavy financial strain; his only assets were his enthusiasm and his industry, combined with an ardent love of nature.

After his death the control of the garden at Forfar passed into the hands of Thomas Drummond, afterwards a member of Franklin's staff during his second Arctic expedition, and subsequently an explorer of some note of the flora of certain parts of America.

James Dickson

Scotland contributed another noted botanist to the scientific world of the period, in James Dickson, after whom L'Heritier named the well-known tree fern, Dicksonia. He was born in a humble position at Traquair in Peeblesshire, in 1737 or 1738, and began life as a gardener. In 1772 he removed to London, and started in business in Covent Garden. He soon attracted the attention of Sir Joseph Banks, who became his friend and helper, giving him access to his library. His chief work lay in the direction of the Cryptogams, on which he became a noted authority. He made several tours in the Highlands between 1785 and 1791, one in 1789 being taken in company with the celebrated traveller, Mungo Park, whose sister Dickson married. His publications were noteworthy; between 1785 and 1801 appeared four volumes, containing descriptions of over 400 cryptogamic plants found in Britain; between 1789 and 1799 seventeen folio fasciculi, each containing twenty-five species of dried plants named on the authority of the Linnean herbarium; in 1795 a work entitled *Catalogus Plantarum Cryptogamicarum Britanniæ*, and between 1793 and 1802 nineteen folio volumes of dried plants. He also published several papers in the Linnean *Transactions*.

Sir J. E. Smith spoke of him as possessed of a "powerful mind, spotless integrity, singular acuteness and accuracy."

Though he was thus noteworthy as a collector of Cryptogams and an authority on species, he exercised but little influence on the progress of botany. He was one of the original members of the Linnean Society and of the Horticultural Society. His death took place in 1822.

Roxburgh

A pupil of Hope may be mentioned here, who was one of the first botanists to investigate the Indian flora, which afterwards played so important a part in the researches of Sir Joseph Hooker in the next century. This was William Roxburgh, who, born in 1751, had his early scientific training at Edinburgh. After graduating he went, while still young, into the medical service of the East India Company, and for several years investigated the plants of India. He was made the Company's botanist in the Carnatic, and ultimately in 1793 became Superintendent of the Botanic Gardens at Calcutta. He retained the post till 1813, when he returned to England, dying two years later. He wrote a *Flora Indica* in two parts, of which he called the first *Hortus Bengalensis*. Of this book he had two manuscripts, one of which he brought home with him and submitted it to Robert Brown. It is now in the Botanical Department of the British Museum. The other manuscript was put into the hands of his successor at Calcutta, Carey, who proposed to publish it in 1820 with additions made later by Dr. Wallich. Only two volumes appeared however, and the matter rested there for some years. In 1832 Carey brought out Roxburgh's manuscript in three 8vo volumes without the Wallich additions. Much later, in 1874, a reprint of it, with the addition of his Indian Cryptogams, was published by C. B. Clarke, and in this form it became a mine of wealth on Indian economic botany.

Menzies

Sir Archibald Menzies was another person of some note in the botanical world towards the end of the eighteenth century. He was born in 1754, of humble parentage, and in his early youth became a gardener under Professor Hope, who seeing in him a lad of much promise helped him to become a student at the University. In 1790 he became naturalist to the expedition made in the *Discovery*

by Vancouver, which visited the Pacific Ocean and North-West America. Menzies brought back a large collection of plants, which were described by Sir J. E. Smith, Robert Brown, and Sir W. J. Hooker.

Menzies had studied surgery at the University, and in his later years he practised it in London. At his death in 1842 he bequeathed a valuable herbarium, rich in grasses, sedges, mosses, and ferns, to the Edinburgh Botanic Garden.

The Glasgow Chair. Thomas and William Hamilton

Botany at Glasgow can hardly be said to have been in a flourishing condition during this period. The subject did not seem to have been at all properly appreciated in the University. As we have seen under Marshall, and subsequently during the time of activity of Cullen, it held its own, but it had always a tendency to sink in the general estimation, and to fall behind in the march of study. Professor Thomas Hamilton seems to have created no enthusiasm; from 1757 to 1781 he held the reins, but he was never a conspicuous figure. For the last four years of his life he was afflicted with palsy, and his son William became associated with him in the discharge of his professorial duties, leaning, however, towards anatomy rather than botany. In 1781, after his father's death, he succeeded to the Chair, which he held with average success till his own death in 1790. Though there was little that calls for notice in either career, it is interesting to find that the records of the botanical department of the University contain a copy of a syllabus of lectures given by either father or son, which are remarkably complete and comprehensive, and indicate that in their teaching there was little to criticise, either as to manner of treatment or scope of the subject. Indeed, if there were no evidence of its date, it might well be taken to have been written during the modern revival.

The garden seems to have been a source of anxiety during these years. In 1762 the gardener, Alexander Adams, who looked after the physic garden for £6 a year, was allowed to have the college garden rent free on condition that he kept it in good order. In 1789 there is the record of the appointment of a new gardener, one Robert Lang. But the garden was small and not well furnished. Professor William Hamilton erected a conservatory, but was compelled to pay for it himself, and when the garden was abandoned in the time of his successor, the latter bought it.

Jeffray

So matters went on. In 1790, on the death of Hamilton, the Professorship was given to Dr. Jeffray, who held it till 1818. But the duties of the Chair, dealing as it did with two subjects, gradually became too onerous for a single occupant. Jeffray conducted the teaching in both botany and anatomy for nine years, but at the end of that time found it necessary to apply for assistance. He was allowed to hand over the botany to the charge of Dr. Thomas Brown, presumably at his own expense. Brown in turn held it for eight or nine years when he resigned, and Jeffray was compelled to resume it. In 1816 he again devolved it, this time to Robert Graham. The strain, however, led to an agitation for the separation of the two subjects, and in 1818 the bond which had lasted for 100 years was broken, and the present Regius Professorship of Botany was established by the Crown. Graham was naturally made the first professor.

Robert Graham

Towards the end of the century the minutes of the Faculty tend to show that the garden fell into desuetude and neglect. From 1760 onwards till 1800 they contain references to supplies and upkeep, but after the latter date they speak of an annual expenditure of £20 " for plants for the botany class," which apparently the garden failed to supply. In 1813 and 1814 there are records of the sale or feuing of parts of it.

About this time the Royal Botanic Institution obtained its charter, and set out at once to found a new botanic garden at Sandyford, towards which the Faculty agreed to subscribe a sum of £2000. The garden consisted of about eight acres of ground; it was furnished with conservatories and other necessary plant, and was properly walled in. The new Professor, Robert Graham, took upon himself the main part of the responsibility for laying it out, which he did with great skill. It was opened to the public in 1819, and by 1822 it contained about 9000 species of plants. The cost of maintenance was about £500 per annum.

Graham's stay at Glasgow was very short. Almost before he had time to settle down in his chair he was appointed to succeed Rutherford at Edinburgh, the post there having been declined as we shall see by Robert Brown. He was a man of considerable ability, which was displayed more fully after his removal.

Beattie

Botany in Aberdeen developed very slowly as part of the University curriculum. One of Skene's successors, Professor James Beattie, was the first man to attain anything of a reputation in botanical circles. He discovered some few plants new to Scotland, and some Carices which proved to be new to science. He sent them to Sir J. E. Smith, the President of the Linnean Society, in whose herbarium they found a place. Beattie taught a small class in botany with considerable success from 1788, and probably numbered among its members the celebrated Robert Brown, to whom all branches of the science subsequently owed so much. Another of his pupils was William Knight, upon whom the teaching largely devolved after Beattie's death, and who ultimately became Professor of Natural Philosophy in Marischal College. For ten years prior to his death in 1810, Beattie taught a class in botany during the college vacation, taking his students with him on herborising excursions. Knight says of him, that he was a good teacher, inspiring his scholars "with his own enthusiasm for the science and thus imposing upon them for life a great interest in the beauties of Nature."

It is probable that the University teaching of botany was supplemented by the efforts of various lecturers who, with the exception of one or two, were without official recognition. They apparently gave courses from 1778 till 1801.

After Beattie's death Knight lectured till 1816. Less known lecturers continued to teach botany till 1823, when Knight was appointed to the Chair of Natural Philosophy. He resumed charge of the subject, though it belonged rather to the Professor of Civil and Natural History. Professor Knight prepared a little book on the *Outlines of Botany* for his class in 1813 before, and again in 1828 after, his appointment.

Edward Hill

As we have seen, some attention was paid in Dublin to the teaching of botany at the beginning of the eighteenth century, but very little progress had been made in those early years. A succession of lecturers followed Nicholson at Trinity College, but nothing of importance transpired till the time of Edward Hill, who was appointed in 1773. There are but scanty records of Hill's career, but what we can learn indicates that a spirit of dissatisfac-

tion with the conditions of the study began to make itself felt. Hill effected the transfer of the old physic garden to a fresh site at Harold's Cross. The cost of both transfer and subsequent maintenance seems to have fallen upon him, and the garden was consequently largely his personal property, but the College seems to have voted it a grant in aid either annually or from time to time.

In 1785 Hill's work was recognised by his being given the status of Professor. He may, therefore, be regarded as the first occupant of the present Chair in the University of Dublin.

One of Hill's friends, Dr. Patrick Browne, attained some eminence as a botanist, explorer, and writer. Born in 1720 he studied the subject at Paris, and subsequently at Leyden, where he graduated in 1743. He came into the circle of the friends of Linnæus, with whom he carried on a correspondence on botanical matters till his death. His own most important work was done in the West Indies, whither he went in 1745. He studied thoroughly the island of Jamaica, and published later a history dealing with its geology, fauna, and flora. In this he arranged his plants, some 1500 in number, according to the Linnean system—one of the first floras to be so presented. Browne returned to Ireland in 1781, bringing with him a large collection of plants, which he presented to Professor Hill, and which apparently formed part of the nucleus of the Trinity College herbarium. He took a deep interest in the flora of Ireland, and intended to prepare a catalogue of Irish plants, a *Flora Hibernica*. He made certain local collections for that object, but his death prevented its completion.

Wade

But it was not only at Trinity College that a scientific spirit was awakened. In 1731 a number of private gentlemen in Dublin founded privately a society which was destined to play a very conspicuous part in the development of science in Ireland. The Dublin Society, as it was first named, was to foster and improve "husbandry, manufactures, and other useful arts and sciences." It first met in the philosophical rooms in Trinity College, later in the Irish House of Lords, and still later in Grafton Street, Dublin. In 1749 the society obtained a Royal Charter of incorporation, and was granted an annual sum of £500 from the privy purse. In 1761 it received for the first time a parliamentary grant.

Early in its career the Dublin Society showed its interest in special branches of science by appointing lecturers in them.

Their first lecturer in botany was Dr. Wade, a physician practising in Dublin, and an ardent botanist. He was a literary man of considerable prominence. In 1794 he published a local flora, "Catalogus Systematicus Plantarum indigenarum in comitata Dublinensi, pars prima." It was written in Latin, and was arranged on the Linnean system, giving the localities of the plants and indexes of their Latin, English, and Irish names. The book is noteworthy as being the first systematic presentation of any part of the Irish flora, and it did a great deal to develop a taste for botany in the country. Wade proposed to publish another volume dealing with the subject on a larger scale, but he did not carry out his design. His second important work appeared in 1804, under the title, *Plantæ rariores in Hibernia inventæ*. He was a keen explorer of the country; he visited Kerry in 1796 and 1805; and searched parts of Connemara in 1801, parts which till then no botanist had visited. He was said to have been the first man to discover *Eriocaulon* in Ireland.

Wade was eminently fitted to do the work of the Dublin Society, and, indeed, he played a very prominent part in carrying out important plans originating with that body. As a result his status was changed from lecturer to professor, and he occupied their Chair of Botany till his death in 1825.

The question of the establishment of a botanic garden in Dublin on an adequate scale began to be debated about 1789, the University garden being small and partly the private property of Professor Hill.

In 1790 the Irish parliament directed its establishment, voting £300 to the Dublin Society towards the purpose. Subsequent grants brought up the fund in 1794 to £1700. The society appointed a committee to consider the question, its members being their own lecturer, Dr. Wade, the University Professor of Botany, Dr. Hill, and Dr. Percival, then secretary to the Royal Irish Academy. In their report the co-operation in the enterprise of the University and of the College of Physicians was sought and accorded. Eventually, however, the Dublin Society was entrusted with the whole management of the funds, and became responsible for the entire scheme.

They speedily acquired sixteen acres of ground near Glasnevin, and in 1795 the formation of this well-known garden was rapidly proceeded with, parliament voting for the purpose a sum of £1300 both in 1798 and 1799. In 1800, £1500 was assigned to the Committee of Agriculture of the Dublin Society for that purpose,

and for the payment of the salary of Dr. Wade, now since 1797 Professor of Botany. Under his management, with John Underwood as head of the practical department, the gardens soon became a centre of technical instruction Among the different departments that were instituted were "the Linnean Garden for the scientific botanist, who studies the plants systematically; the Cattle Garden; the Hay Garden; the Esculent Garden; the Dyer's Garden; the Irish Garden; etc." Lectures on general botany were given by the Professor, "and also separate lectures on the Cattle and Hay Gardens for the instruction of the common farmers, their servants and labouring men," all of whom were admitted to the lectures without payment. Similar lectures were given "for the dyers' use and for the purpose of extending practical knowledge, particularly in husbandry."

Underwood, the curator, published in 1801, "A Systematic Catalogue of Greenhouse and Hothouse Plants in the Dublin Society's Botanical Garden at Glasnevin," which contains a plan and elevation of the hothouses and greenhouses existing at the time. They comprised a large central conservatory, with two greenhouses on the one side, and a hothouse and stove on the other, and were situated with their ends facing the south, where the walk now leads from the entrance gate to the Octagon House. They were connected by a corridor with the house now occupied by the Curator, to the south-west end of which another greenhouse was attached.

A systematic catalogue of the arboretum, fruticetum, and herbarium was published by Underwood in 1802.

By the year 1813 the exotics cultivated at Glasnevin had increased to such an extent that a range of three additional small houses was erected near the entrance gate, and two years later two handsome entrance gates were presented to the gardens by Mr. Pleasants, one of the members of the Dublin Society. The principal range of hothouses proved after a few years to have been badly constructed and placed in an unsuitable situation. It was therefore removed in 1817-18 to the site where the large palmhouse now stands, and in 1819 the Octagon House, forty feet high, was erected.

Scott

Professor Hill, as we have seen, laid the foundation of the herbarium of Trinity College, when he presented to it the West Indian collection of Dr. Browne. He did not appear, however,

to have developed it further. He occupied his Chair till 1799, when he resigned and retired into private life. So long as he was Professor he kept up his botanical garden near Harold's Cross, the cost being partly defrayed by the Board, and on his retirement he handed it over to the College, receiving as compensation the sum of £618 19*s*. 8*d*., a sum agreed upon as the result of arbitration in 1803. Hill died in 1815.

In 1800 Dr. Robert Scott was elected Professor of Botany. Much of his time was occupied in purely administrative work, but he achieved some reputation as a botanist, being principally interested in the group of the Mosses, of which he made a special study. He was a friend and correspondent of Dawson Turner, the father-in-law of Dr. Joseph Hooker. The management of the garden was one of his first cares ; in 1801 he procured the appointment of a Curator, and in 1805 the stipend of this new officer was fixed at £130 per annum, out of which he paid the wages of two labourers all the year, and two others from March to December.

In 1804 Scott secured the assistance of Dr. J. T. Mackay, who had then occupied several horticultural posts in Scotland. He acted at first as assistant botanist in the College, being occupied during some months in each year in teaching medical and other students. When not so occupied he was engaged, partly at the expense of the Board, in elucidating the flora of the country. In 1804 and 1805 he conducted explorations in the west, after the example of Wade a few years earlier. As a result he published in the *Transactions* of the Dublin Society in 1806 a catalogue of the rarer plants of Ireland which ultimately formed the basis of two larger works, a catalogue of the indigenous plants of Ireland in 1825, and the *Flora Hibernica* of 1836.

The foundation of the present botanical garden of Trinity College dates back to 1806. Acting on the advice of Scott in July of that year the Board of the College leased a small piece of ground near Ball's Bridge for this purpose. Situated about a mile from the College, it comprised about three acres, and was held for 175 years at a rent of fifteen guineas an acre. Dr. Mackay was appointed the first Curator, and was chiefly responsible for its laying out. The walls enclosing the area were built in 1807, and the planting of trees, shrubs, and herbaceous plants commenced in 1808.

With the establishment of the garden Scott's term of office came to a close. Like his predecessor he resigned the Professorship, retiring in 1809.

The College gardens became well known under Mackay, and were visited by Sir W. J. Hooker, Lindley, Paxton, the MacNabs, Loudon, and other distinguished gardeners and botanists. Several of Mackay's pupils became famous, *e.g.* David Moore, Fraser, the landscape gardener, Balfe, Secretary of the Dublin Horticultural Society, Charles Moore, afterwards director of the Sydney Botanic Gardens, and Bain, Mackay's own successor.

The soil of the garden was a light sandy loam, resting on old river beds or creeks that at one time extended inland from the shore.

William Allman

Scott's successor in the Chair of Botany was Professor William Allman, a native of Jamaica, whose parents removed to Ireland when he was only four years of age. He was a graduate of the University of Dublin, and for some years previous to his appointment he practised medicine at Clonmell. The early part of his tenure of the Professorship was uneventful, except for the introduction of the natural system of classification into his lectures. This was probably due to his close friendship with the great Robert Brown, who did so much to bring this system into favour with the botanical world. Professor Allman's teaching took that direction in 1812; he published a syllabus of his lectures in 1817. He wrote but little on botanical science; a memoir read before the Royal Society in 1811, on a "Mathematical Connexion between the Parts of Vegetables," is now in manuscript in the herbarium of the British Museum.

Little more transpired in Ireland that calls for comment before the close of the period under discussion. It may be noted that in 1820 the Dublin Society assumed the prefix of "Royal" under an autograph letter of George IV.

CHAPTER XXXII

VEGETABLE PHYSIOLOGY IN ENGLAND, 1760-1820

INVESTIGATION of physiological questions in England did not pursue a steady course, but rather attracted attention with a strange intermittence. We have seen that an interval of nearly forty years separated Grew and Hales, and that no development of any kind occurred during the whole period. With the cessation of Hales's activity the subject again slumbered, and no progress was made till nearly the end of the century. Then occurred a fresh outburst on a larger scale, and attention was directed with remarkable results to two of the most important series of problems awaiting examination. The first was the great question of the nutrition of plants, and the way in which they manufacture their food. In this field the new ideas had their origin in England, though the subsequent development of those ideas occurred in Switzerland. The second was the relationship between the plant and its surroundings, more especially the influences exerted by the latter. Here England stood pre-eminent. During the years with which this chapter is concerned certain fundamental ideas on both these questions were established by experimental proof, though the superstructure built at the moment upon them was but very imperfect. There was no knowledge of the living substance of the plant, and curious ideas obtained as to how it lived, and in what its life consisted, and the workers were compelled to interpret their experiments by purely mechanical conceptions.

A third problem also attracted attention—the old problem at which Hales had done so much—the circulation of the sap. Here still the central idea was that the circulating sap is the nutrient fluid, much as the blood is in the human body.

Priestley

The new chapter in the development of vegetable physiology opens, strange to say, with the work not of a botanist, but of a chemist—one of the most distinguished of the time, whose great work in his own science was the investigation of air and subse-

quently of various gases to which his original discoveries led him. This was Joseph Priestley, the discoverer of oxygen. Little of his work has a botanical bearing, and the importance of his discoveries from the botanical point of view did not make its due impression upon him. His standpoint was entirely chemical, and his research, so far as vegetation was concerned, was altogether the influence plants have on the air, and not at all the reciprocal influence the air exercises upon them. His work dates from 1771, though the publication of it did not begin till 1775. The great discovery which concerns us here is stated in the following words: "I have been so happy as by accident to have hit upon a method of restoring air which has been injured by the burning of candles, and to have discovered at least one of the restoratives which Nature employs for this purpose. It is *vegetation*. This restoration of vitiated air, I conjecture, is effected by plants imbibing the phlogistic matter with which it is overloaded by the burning of inflammable bodies. But whether there be any foundation for this conjecture or not, the fact is I think indisputable. . . . One might have imagined that since common air is necessary to vegetable as well as to animal life, both plants and animals had affected it in the same manner; and I own that I had that expectation when I first put a sprig of mint into a glass jar standing inverted in a vessel of water. . . . Accordingly on the 17th of August 1771 I put a sprig of mint into a quantity of air in which a wax candle had burned out and found that on the 27th of the same month another candle burned perfectly well in it. . . . Several times I divided the quantity of air in which the candle had burned out into two parts, and putting the plant into one of them, left the other in the same exposure, contained also in a glass vessel immersed in water, but without any plant, and never failed to find that a candle would burn in the former but not in the latter."

In 1778 he noticed a green deposit in some vessels which he had used in his experiments, and found that it gave off very "pure air." He examined its behaviour more closely and found that this exhalation took place only during exposure to sunlight. This green deposit was afterwards found to consist of Algæ.

Ingen-Housz

Priestley's results attracted the attention of another investigator who was more concerned with the botanical aspect of the question,

though he too was disposed to lay the first stress on the condition of the air under the influence of vegetation. His work was, however, based upon Priestley's discoveries. This was Ingen-Housz, who may be said to have laid the foundation of the modern conception of the nutrition of plants.

Ingen-Housz was born at Breda in 1730, and was educated for the medical profession. He practised for six years in the Netherlands, and in 1764 or 1765 he transferred his residence to England. In 1768 he went to live in Vienna, where he was made physician to Joseph II., and where for several years he continued to reside. His leanings for some reason were always towards England, and when he began to publish scientific papers he sent them to the Royal Society. His first memoir appeared in 1775, and it was followed during after years by eight others. In 1779 he returned to London, and was made a Fellow of the Royal Society. Most of his remaining years were spent in England. He died in 1799.

Besides his papers in the *Philosophical Transactions* he published in England his first great work, dedicating it to Sir John Pringle, the President of the Royal Society, in recognition of the kindness and sympathy he had received. It bears the title, "Experiments on Vegetables, discovering their great power of purifying the common air in sunshine, but injuring it in the shade or at night," and the date 1779. It appeared subsequently in a French translation, made by himself, published in Paris in 1787-89.

In this book we have for the first time brought out the influence of light upon the gaseous interchange which Priestley noted. The author describes it in the following words: "I was not long engaged in this enquiry before I saw a most important scene opened to my view. I observed that *plants not only have a faculty to correct bad air in* 6 *or* 10 *days by growing in it as the experiments of Dr. Priestley indicate, but that they perform this important office in a compleat manner in a few hours; that this wonderful operation is by no means owing to the vegetation of the plant, but to the influence of the sun upon the plants*. . . . I find that plants have, moreover, a most surprising faculty of elaborating the air which they contain, and undoubtedly absorb continually from the common atmosphere, into real and fine dephlogisticated air; that they pour down continually a shower of this depurated air." Dephlogisticated air was the name Priestley gave to the gas we now know as oxygen.

Ingen-Housz goes on a little later to say, "that plants shaded by high buildings or growing under a dark shade of other plants do not perform this office, but on the contrary throw out an air

hurtful to animals and even contaminate the air which surrounds them."

In this last pronouncement we have the first intimation of the true respiratory process to which Ingen-Housz gave his attention a few years later.

By other experiments he showed that the influence of the sun lay in its illuminating and not its heating powers; also that it is only the leaves and other green parts of the plant which improve the air.

Ingen-Housz says in the preface to the volume, that the purification of the air as discovered by Priestley serves the plants as a kind of nourishment. We have seen that Hales had already advanced the view that part of the nutritive matter of the plant is derived from the atmosphere. Ingen-Housz carried the idea somewhat farther, but in this early work made no definite pronouncement on this more complicated question. Even the proof afforded by the recognition that a gain in weight is associated with the gaseous interchange had to wait for the appearance of De Saussure.

Ingen-Housz, moreover, did not in this book indicate what constituent of the impure air was removed by the plant. The absorption of "fixed air" did not attract his attention.

The experiments on which the author based his book as well as the book itself were associated with England, though Ingen-Housz himself was not of English nationality. He says they were conducted in England during the three months from June to September 1779; that he performed 500 experiments during that time, working from morning till night.

Had the quotations made stood alone, they would give an inaccurate account of his views on gaseous interchange, lending support to an idea which became strangely prevalent later, that plants absorb oxygen and give off carbon dioxide during the night and reverse the process by day, the two processes passing as nocturnal and diurnal respiration respectively. But Ingen-Housz had much clearer views than these. He says later in the same book that his experiments showed him that plants *incessantly* gave out impure air, an indication that he knew the true respiratory process to be perfectly dissociated from the purification of the air in sunlight.

This question of respiration and its conditions was examined by him in the years succeeding the publication of his first work, and a fuller discussion of it was published by him in Vienna in 1786. He did not, however, keep the processes of respiration and carbon

appropriation equally prominent. In Section 12 of the *Experiments*, he speaks of the yield of " bad air " by night as quite inconsiderable in comparison with the diurnal output of dephlogisticated air.

In 1796 he sent to the Board of Agriculture an essay on the food of plants and the renovation of soils. In this he presented his views with greater definiteness, being enabled to do so by the discoveries that had been made in chemistry during the interval.

It is thus to Ingen-Housz that we owe the first clear statement of the respiratory process in plants and the beginning of our knowledge of the photosynthetic interchanges, which he carefully distinguished from the others. His association of the absorption of the impure air with nutrition is not so clearly stated, but that he believed it played a large part therein is evident from his remark that if all a plant's food is derived from the soil, it is scarcely conceivable that a large tree should find its food for hundreds of years in the same spot.

His work was the last carried out in England for many years upon this section of vegetable physiology. Though in the period which followed substantial additions were made to our knowledge, the work which determined them was done on the Continent, the contributions of Senebier and particularly of De Saussure being made in Switzerland. England, indeed, lagged behind in this field till well past the middle of the nineteenth century.

Knight

The second line of research which now calls for comment was undertaken by Thomas Andrew Knight, who in many respects may be looked upon as the successor of Hales. Knight was born in 1759 and after receiving his early education at private schools entered Balliol College, Oxford, about 1778. His parents were in easy circumstances, and on the death of his father he became himself a country squire. His life thus fortunately endowed was devoted to scientific pursuits, and in all other respects was fairly uneventful. He married in 1791 and settled down at Elton in Herefordshire ; he removed to Downton in 1809 and resided there till his death in 1838.

The starting of his scientific career was much facilitated by his making the acquaintance of Banks soon after his marriage. But at that time the Board of Agriculture wanted certain information in the shape of replies to a series of questions, and desired that the

inquiries should be answered from several districts, and Banks was applied to for the names of properly qualified men. He was acquainted with Knight's brother, and knowing him to occupy an influential position in Herefordshire asked him to suggest a correspondent for that part of the country. He nominated his brother, who was thus made acquainted with Banks. The latter soon found that Knight had been working at various problems of vegetable physiology, and had deduced important theories from his experiments. Interested as he was in the work of the Royal Society, Banks regarded him as a valuable auxiliary, and pressed him to publish his results. The result was that Knight became a constant visitor at Soho Square, and was there thrown into contact with the most distinguished men of the time in science and literature. He continued to contribute papers for many years to the *Philosophical Transactions*, the first appearing in 1795, the last in 1814.

In 1805 he was elected a Fellow of the Royal Society, and in 1806 the Copley Medal was awarded to him for his researches in vegetable physiology. Among the men he met at Soho Square was Sir Humphrey Davy, with whom he formed a life-long friendship. In 1803 Davy was about to deliver a course of lectures before the Board of Agriculture on agricultural chemistry, and was aided by Knight on certain points of physiology, a subject with which he did not feel himself fully competent to deal. Their relations at once became of the most cordial character.

In 1804 the Horticultural Society was founded, through the influence and efforts of Wedgewood, Banks, Forsyth of Chelsea, Aiton of Kew, and others, and Knight was nominated as an original member. This society was associated with much of Knight's work in later years, and its *Transactions* contain many of his papers, most of which, especially some on hybridisation, were eminently practical. At the death of Lord Dartmouth, the first President, in 1810, Knight was elected to succeed him, and he occupied the Chair till his death.

His earliest scientific work, published in 1801, was concerned with the idea of the circulation of the sap which we saw had taken so firm a hold of his predecessor, Hales. His views of the circulating sap show that he was impressed with the idea that it played the same part in a plant as does the circulating blood in an animal. "By these," he says, speaking of the alburnum and central vessels of the wood, "the sap is carried into the leaves and exposed to the air and light; there it seems to acquire (by what means I

shall not attempt to decide) the power to generate the various inflammable substances that are found in the plant. It appears to be then brought back again through the vessels of the leaf-stalk to the bark, and by that to be conveyed to every part of the tree to add new matter, and to compose its various organs for the succeeding season."

It is important in estimating Knight's work on this subject to recognise what was his opinion of nutrition. Here is clearly the view that the sap of vegetables is analogous with the blood of animals. The office of the leaf is subordinate; something is added there to the sap, but the sap itself is the great factor. He had not adopted even the discoveries and hypothesis of Ingen-Housz, in which the importance of the leaf as the seat of manufacture of food had been set out. We miss altogether the idea that the leaf is the laboratory, and that the function of the sap is to supply it with raw materials and to remove the manufactured products, a view to the acceptance of which the work of Ingen-Housz was really the first step. A few years later, in 1805, he seems to have attributed, however, "the preparation of matter calculated to afford food to the expanding buds of the succeeding spring," but he held that this was confined to the autumn. He pressed very far the analogy between the sap and blood in plant and animal circulation, for he held that the bark vessels are analogous to veins, and suspected that, like the latter, they might have valves in them to aid in the regulation of the flow.

It is important to realise Knight's position in examining his work on the ascent and descent of the sap, which appeared in the publications of the Royal Society in 1801 and 1803, and which contained much that was not only instructive for the time, but was destined to remain with little modification among the fundamental facts of the science.

He made his early experiments by the method of *ringing*. In some of them he removed the external parts of a narrow zone of the exterior of a tree, making his incisions down to the wood and taking away what he considered the "bark," but which went beyond the limits now ascribed to bark and, indeed, included the cambium, a tissue which had not then been identified. In other experiments he extracted not only this ring of "bark," but by skilful dissection he removed also the pith. Having prepared his stems in this way, he observed the effects of subsequent growth, finding that above the wound or ring the buds developed normally, while below it at first there was no growth at all. Hence he

concluded the path of the ascending sap to be the "alburnum," and that of the descending stream to be the "bark." He confirmed this conclusion by cutting off branches below the rings he had made upon them, and immersing the cut ends in a liquid, coloured by an infusion of the skins of black grapes; after a time he found the water to rise in the branch, passing up "the pores of the wood," staining them as it went, but not colouring "the bark, nor the sap between it and the wood."

Knight made many observations on both stems and petioles by this method and obtained satisfactory evidence of the path the ascending stream pursues.

He found further that when buds were left on the region of the stem below the ring, after a time they grew into shoots and the parts of the stem below the wound resumed their increase in thickness; an increase which, however, did not affect the region between the top bud and the ring, if the distance were of any great length. Herein he clearly showed how dependent the growth of the stem is on the activity of the leaves which normally it bears. Hence he deduced the view that the downward flow takes place in the "bark." But, as we have seen, he knew next to nothing of what the difference between the ascending and descending sap consisted in, nor how it was brought about. The growth of the buds above the wound only suggested that it had become "elaborated," and hence more nutritive than before. Again, his view as to the pathway by which nutritive substances pass out of the leaves was sound so far as the anatomical knowledge of the time enabled him to go. If bast be substituted for bark and the limits of the bark be recognised as lying outside the bast his view is quite in harmony with modern ideas.

Knight's views on the anatomy of the parts concerned were also sound. He delimited one set of vessels in the wood, another external to it; he found two classes of vessels or tubes in the leaf and petiole, one kind of which only conveyed his staining fluids. He combated the view of Hales that the bark is derived from the alburnum, and opposed also the statement of Linnæus that the inner bark becomes alburnum. He must have seen the bast, for he said it persists, and forms annual rings or layers in the bark, each of which once formed its vascular lining.

The descent of the sap did not yield him so much satisfaction. He devoted himself chiefly to efforts to ascertain its cause, which he could not determine. He thought it to be in the main an effect of gravitation, though he considered the free movement of

the stem and branches caused by wind would have a certain influence.

He incidentally studied certain of the phenomena of transpiration, or "perspiration," as it was then called. He proved that it was chiefly conducted by the lower surface of the leaf; and he associated the upper surface erroneously with the absorption of moisture as well as of "operating by the influence of light." He had no adequate idea of the powers of absorption of the root, for he thought that the copious perspiration that went on, demanded a large water reservoir in the plant, which he held it to be the particular office of the pith to supply.

Nor was he very happy in his ideas as to the forces causing the ascent of the sap. After quoting the views of Hales and of Linnæus, he goes on to attribute it to the continual expansion and contraction of the "silver grain" as it is acted upon by heat.

In all this work we see how little Knight was in advance of Hales. His fundamental conception was the same; he attacked the same problems though by new methods, but he did not carry them very much further towards solution. Nor was he any clearer upon the meaning of transpiration or the functions of the leaf. The great question of the forces at work in raising the stream of water showed him actually behind Hales; he gave up the deductions of his predecessor in favour of a new theory which did not stand the test of further investigation.

On another question connected with nutrition Knight made some important observations. "I have been led to imagine that the leaves both of trees and herbaceous plants are alike employed during the latter part of the summer in the preparation of matter calculated to afford food to the expanding buds and blossoms of the succeeding spring." Here we have a very clear reference to the process of deposition of reserve materials.

But Knight's reputation as a vegetable physiologist rests on the remarkable discoveries which he made on the power which plants possess of in some way appreciating and responding to the conditions of their environment. His acquaintance with these phenomena was not perfect, and his interpretation lacks much of what is at the present day believed. He had no belief in sensitivity as we now understand it, and sought a mechanical explanation of what he observed, but he, nevertheless, investigated the phenomena of geotropism and of negative heliotropism with a skill that still commands the admiration of all workers at kindred problems.

His most important paper was communicated to the Royal

Society in January 1806. He tells us that he was led to the consideration of the subject by the observation that in whatever positions seeds were placed during germination, as soon as the seedling emerged "its radicle invariably makes an effort to descend towards the centre of the earth, while the elongated germen takes a precisely opposite direction," and by the fact that "some naturalists have supposed these opposite effects to be produced by gravitation." What was then a matter of supposition only Knight put to the test of experiment. "As gravitation could produce these effects only while the seed remained at rest, and in the same position relative to the attraction of the earth, I imagined that its operation would become suspended by constant and rapid change of the position of the germinating seed, and that it might be counteracted by the agency of centrifugal force." This was a flash almost of inspiration, one of those wonderful intuitions which are so rare, but which when they are realised start out new trains of thought and open the way to undreamed-of results. It carries with it, had its author but realised it, the very important question of the power of perception, which was then by almost universal consent denied to plants. Sachs says of it that it was "a brilliant discovery which was extremely inconvenient to the thorough-going adherents of the nature-philosophy and the vital force, and did much to bring the scientific study of the movements of plants back to the right path." Knight's way of testing his theory was to place seeds to germinate on the circumference of a wheel revolving rapidly on a horizontal axis. "The radicles of these seeds were made to point in every direction, some towards the centre of the wheel and others in the opposite direction ; others as tangents to its curve, some pointing backwards, and others forwards, relative to its motion ; and others pointing in opposite directions in lines parallel with the axis of the wheel." The wheel was made to revolve by means of a stream of water at a rate of 150 revolutions per minute, the centrifugal force thus generated being in excess of the force of gravitation. "In a few days the seeds began to germinate . . . and I had soon the pleasure to see that the radicles in whatever direction they were protruded from the position of the seed, turned their points outwards from the circumference of the wheel, and in their subsequent growth receded nearly at right angles from its axis. The germens, on the contrary, took the opposite direction, and in a few days their points all met in the centre wheel."

After this first experiment Knight added a horizontal wheel to

his apparatus, and sowed beans around its circumference as before. He rotated this new wheel at different rates, studying the effect upon the position of the seedlings which the combined action of gravity and of centrifugal force would bring about. As he expected, the position assumed was that of the resultant of the two forces now at work. With a rotation of 250 turns per minute, he says: "The difference I had anticipated between the effects of rapid vertical and horizontal motion soon became sufficiently obvious. The radicles pointed downwards about 10 degrees below, and the germens as many degrees above, the horizontal line of the wheel's motion; centrifugal force having made both to deviate 80° from the perpendicular direction each would have taken, had it vegetated at rest. Gradually diminishing the rapidity of the motion of the horizontal wheel, the radicles descended more perpendicularly, and the germens grew more upright; and when it did not perform more than 80 revolutions in a minute, the radicle pointed about 45° below, and the germen as much above, the horizontal line, the one always receding from, and the other approaching to, the axis of the wheel."

Knight's explanation of these curvatures was a mechanical one. He was a firm believer in utility as a factor in the life of a plant, but he shrank from admitting openly any idea of stimulation and response, or as he put it of "sensation." Hence he tried to explain the curvatures of geotropism by physical processes. Of the behaviour of the root he says: "the new matter which is . . . added unquestionably descends in a fluid state from the cotyledons. On this fluid, and on the vegetable fibres and vessels while soft and flexible, and whilst the matter which composes them is changing from a fluid to a solid state, gravitation, I conceive, would operate sufficiently to give an inclination downwards to the point of the radicle." In other words, he thought the tip of the radicle bent downwards from its own weight. He explains the upward bending of the young shoot or germen differently. "The germen . . . elongates by a general extension of its parts previously organised; . . . if the motion consequent to distribution of the true sap be influenced by gravitation, it follows that when the germen . . . deviates from a perpendicular direction the sap must accumulate on its under side; I have found . . . that the vessels and fibres on the under side of the germen invariably elongate much more rapidly than those on its upper side; and thence it follows that the point of the germen must always turn upwards."

In 1810 Knight turned his attention in greater detail to the

phenomena accompanying the growth of roots, examining their relation to the soil and to water as well as to gravitation. His experiments were very ingeniously devised, and they led him to the conclusion that the root while growing was much affected by the neighbourhood of moisture; that the latter could, when supplied only to one side of the growing organ, counteract the effect of gravity, and if conditions were properly adjusted could be made to grow vertically upwards. That the phenomenon was due to the influence of water became evident when a root so affected was supplied with water equally all around it; it then grew downwards in a normal way.

Here we have a very near approach to a perception of the peculiarities now known as hydrotropism. Again Knight failed to see the full bearing of his own discovery.

In the next year and the early part of 1812 Knight observed the curious tendency of the tendrils of Ampelopsis and of Vitis to grow in a direction opposite to the incidence of light. He found the same peculiarity in the "claws or claspers" of the Ivy, as he did in subsequent experiments in the stems of these three plants, and noted that a seedling plant of the peach did not behave similarly. This discovery of what we now call negative heliotropism again received but a partial explanation. Knight accounted, however, for the curvature of the tendrils with considerable plausibility: "The external pressure of any body upon one side of a tendril will probably drive the fluid organisable matter from one side of the tendril, which will consequently contract to the opposite side, which will expand, and the tendril will thence be compelled to bend round a slender bar of wood."

Some passages in his earlier paper of 1801 indicate that he had thus early observed the phenomena of diaheliotropism in leaves. He says: "I will request your attention to the power of moving in the vine leaf, on which I have made many experiments. It is well known that this organ always places itself so that the light falls upon its upper surface, and that if moved from that position it will immediately endeavour to regain it; but the extent of the efforts it will make, I have not anywhere seen noticed. I have very frequently placed the leaf of a vine in such a position, that the sun has shone strongly on its under surface; and I have afterwards put obstacles in its way on which ever side it attempted to escape. In this position the leaf has tried almost every method possible to turn its proper surface to the light." This observation seems to anticipate Darwin.

It is strange that with so many instances of response to stimulation before him Knight should have closed his eyes to what seems to us a very obvious interpretation of them all, the possession of sensitiveness and of the power of response to stimulation, particularly as in the eighteenth century the possession of "feeling" had been claimed for plants both by Dr. Percival and by the Bishop of Llandaff. But as we have noticed he was a strong opponent of the old nature philosophy and of the peculiar dogma of the "vital force" which then was entertained by many of the continental botanists and in his opposition he went too far in his adhesion to purely mechanical explanations. He denied in so many words the existence of sensitivity: "I am wholly unable to trace the existence of anything like sensation or intellect in the plants." Possibly in his hostility to the latter, he associated the two more closely together than he intended, for in his discussion of the phenomena of growth in the vine under different conditions, when speaking of the effect of rising temperature, he alludes to such rise as causing "stimulation." In his description of the diaheliotropic phenomena of the leaf he says: "As the whole effect here produced appears to arise merely from the light falling on the under surface of the leaf, I cannot conceive how the contortions of its stalk, in every direction, can be accounted for without admitting not only that the plant possesses an intrinsic power of moving, but that it also possesses some vehicle of irritation." He uses, too, a curious phrase in a letter to Sir Joseph Banks in 1799, when speaking of the silver grain of the wood working to force the ascending sap upwards by contracting and expanding under variations of temperature: "All bodies being more or less expansible by heat, and the silver grain appearing to be of a very *irritable temper*." Knight also contributed some experimental work to the study of the problem of hybridisation, carrying out researches especially among the Leguminosæ.

As a man of science and an investigator Knight must always command our admiration. He had much of the unwearied patience and perseverance of Hales, and, indeed, much resembled him in his way of reasoning and drawing conclusions from his experiments. In personal demeanour he was possessed of the same geniality and charm which appeared so admirable in Ray. He was greatly attached to the idea of the utility of the processes he was investigating, and was probably guided by this consideration in the selection of the problems which he tried to solve. He was a faithful friend, warm-hearted and generous; sometimes, indeed, he let the

warmth of his feelings hinder the free play of his judgment. A little impulsive, but fully prepared to admit himself to be in error when he recognised the fact, he was a man of the strictest honour and impartiality. Nor was he devoid of a sense of humour; in one of his letters he says, possibly remembering some experiences of a somewhat discouraging nature, "short papers, like short sermons to most congregations, are more agreeable to the members of the Royal Society, some of whom come there with rather a strong propensity to fall asleep."

This period was one of great activity in the pursuit of the questions connected with the functions of the flower. It saw new departures made and investigation renewed into the general questions of pollination. The scope of the latter was greatly enlarged by the introduction of hybridisation, which began to be critically examined. It was not altogether a new problem for an instance of it had been brought to the notice of Bradley, as we have already seen. But what was then deemed merely curious now became a subject attracting keen interest. Speculations were indulged in also as to the fate of the pollen after its arrival on the stigma, and more than one theory was advanced, but little or no advance was made in actual knowledge of this point till after 1820.

Though much attention was paid to these questions elsewhere, comparatively nothing was done in England. It was the age of Kohlreuter and Sprengel in Germany, and nearly all the advance that was made was associated with the name of one or other of them.

Still in England the question was not altogether neglected. Knight, after the foundation of the Horticultural Society, took up the question of hybridisation with a view to improving the various fruits whose cultivation the society encouraged, and was successful in introducing many new varieties. On the scientific side he examined the question of the relative advantages of cross- and self-pollination within the limits of species, and came to the conclusion that no species fertilises its flowers each with its own pollen through an indefinite number of generations.

In a department of physiology which at the time appealed to very few investigators, that, namely, which embraces questions of sensitiveness, we have called attention to the old appreciation of its importance by one or two workers in the eighteenth century. Though it was opposed by Knight there were other writers who had no doubt as to its existence. Sir James E. Smith was one of

these. He left on record some experiments which clearly demonstrated the existence of irritability or sensitiveness in the stamens of *Berberis*. In a paper read before the Royal Society on February 14, 1788, he said: "With a very small bit of stick I gently touched the inside of one of the filaments, which instantly sprang from the petal with considerable force striking its *anthera* against the stigma. I repeated the experiment a great number of times, in each flower touching one filament after another, till the anthers of all six were brought together in the center, over the stigma." In other experiments he localised with considerable accuracy the sensitive area. Though he interpreted his experiments wrongly as proving self-pollination of the flower, he clearly proved a local sensitiveness, traversing the views of Jung and of Linnæus.

Morphology and anatomy were not altogether overlooked during this period, but there was little progress till its closing years. These were so noteworthy as being associated with the early researches of Robert Brown, who figured so largely during the first half of the nineteenth century, that it will be best to postpone the consideration of this part of his work till we discuss his career as a whole in the next chapter.

BOOK V

THE REVIVAL OF THE NATURAL SYSTEM UNDER BROWN AND LINDLEY

BOOK V

CHAPTER XXXIII

THE LIFE OF ROBERT BROWN

It was inevitable that the supremacy of the Linnean system with its assumption of finality and its consequent obstruction of research should be only transitory. The wonder is not that it ultimately disappeared, but that it held its place so long. Though it became dominant over England and the parts of the Continent which were the scene of its great founder's labours, it was not universally accepted. In France it never made any substantial progress; there the efforts of the De Jussieus were put forward in search of the natural system, while the imperfections of its rival were gradually making themselves felt in England and Sweden. By the beginning of the nineteenth century its shortcomings became more and more obvious, and its opposition to progress more and more recognisable, even where the greatest attachment was felt for it; so that the support of all but the most bigoted of the followers of Linnæus was being rapidly alienated. During the first decade of the century it lost ground more and more, and it became evident that its final disappearance could not be long deferred.

At this period of unrest England saw the advent of a long line of taxonomists of the greatest brilliance, who not only outshone all their predecessors, but carried the nation's prestige in botany to a pitch that had not been reached even under the influence of Ray. Their influence again gave the supreme place to English thought, great as were the writings of the French school, from the earliest De Jussieu to the latest De Candolle. While the latter shone by their brilliant speculations combined with their assiduous study of family after family of plants, the Englishmen were in no way their inferiors in the study and the herbarium. Further, they combined with such labours the work of almost world-wide exploration, giving such an impetus to the study of the vegetation of the earth as had never been known before, and laying the

foundations of the science of geographical botany, thereby accumulating the materials destined to form the basis of the great speculations on the fixity or mutability of species, which marked the closing years of the century.

As it was inevitable that the Linnean system should disappear, so it was certain that its departure should be the result of such work as the English school achieved. At first no determined stand was made against the artificial system; it was gradually superseded by more satisfactory views, and died not from an active propaganda, but from its own inanition.

The new movement began with the explorations and writings of Robert Brown, the most remarkable botanist of his time, and certainly the greatest genius England had so far produced—a man who united a calm, reflecting, and philosophic spirit to an intense devotion to the investigation of botanical problems, both systematic and physiological. Though Robert Brown was the first he was no isolated figure. In his lifetime he had colleagues who were little less illustrious than himself, men who, perhaps, exerted more influence on the progress of events than even he did. Lindley was a contemporary of his later life—a man whose dissatisfaction with the artificial system led him to formulate system after system on so-called natural lines, plans which, while they took no permanent place in history, yet were productive of much minute research into questions of true affinity, and led the way to a more accurate idea as to what true relationship consists in. Next in the line of succession came the Hookers, father and son, who completed the revolution of the science, and through whose genius for administration was due the construction of the great national garden at Kew as we now know it. But to deal in detail with the careers of these two historic figures would be to give the story of the greater part of the century. Nothing botanical in the course of the nation's life has ever approached their achievements. Nor must another great personality remain unnoted here, George Bentham the traveller, taxonomist, and philosopher, who was associated with the younger Hooker in the preparation of the most famous English work of the century, the *Genera Plantarum*.

Nor must we omit to mention that the new century saw progress of the greatest value in other than taxonomic fields. These results, however, will naturally fall into their places side by side with those of the great men of whom we have been speaking. The chapter of the development of botanical science begins with the

establishment of the new natural system, heralded as it was by the work of Robert Brown.

The son of a Scottish clergyman, he was born at Montrose in 1773, and was educated at the grammar school there, whence he proceeded to the University of Aberdeen. He won at his entrance a bursary (though of small value), the object of the first ambition of so many Scottish students, and soon gave evidence of great ability. His parents removing to Edinburgh two years afterwards, he transferred his studies to the University in the metropolis where he devoted himself to the medical profession, but did not proceed to a degree. Both in Aberdeen and in Edinburgh he applied himself in his leisure hours to the study of the flora, to which he brought an untiring industry, an accuracy of observation, and a keenness of perception which characterised him throughout all his subsequent career. At the age of eighteen he contributed to the Natural History Society of Edinburgh a list of all the plants described in Scotland since the publication of the *Flora Scotica* of Lightfoot, many of them his own discoveries. This work led to an acquaintance with Withering and indirectly with Sir Joseph Banks. In 1795 Brown joined the army, and was with his regiment in Ireland for three years. During this time he employed much of his leisure in botanical exploration and so increased his reputation. Having been detached to England for recruiting purposes, he was cordially received by Banks, who placed at his disposal the resources of his library as well as the large collections of plants which he had amassed, and which were at the time under the care of Dryander.

Brown returned to Ireland in 1799, but left the army the next year, to join the expedition of Captain Flinders to New Holland. No doubt this step was taken mainly at the suggestion of Sir Joseph Banks, who recognised in Brown the qualities which go to make the naturalist, and which are seldom met with so fully matured as in this case. There is every evidence that Brown's heart was much more in the scientific recreations of his leisure than in the routine of military life, and it is not surprising that Banks's invitation was heartily responded to. Brown left the army at once, made his preparations for a few years' absence and sailed with Flinders in 1801, an accomplished botanist and an enthusiastic pioneer. He was accompanied by Ferdinand Bauer, to whom reference has already been made, and to whose wonderful skill in botanical drawing science became afterwards deeply indebted.

It is impossible here to follow the course of the voyage in detail. The south coast, the tropical part of the east coast, and parts of the north coast of Australia had been explored, when the state of the ship compelled Flinders to return to England. The botanists remained in Australia for a further eighteen months, and extended their explorations beyond the mainland into the island of Van Diemen's Land, and Kent's Islands in Bass's Strait. The plants they accumulated during the whole time numbered nearly 3900 species, all of which were safely brought home to England. About three-quarters of this number proved to be new to science ; indeed, the flora of Australia exhibited exceptional features of great interest and opened up many problems connected with geographical distribution.

Brown's behaviour upon the way home throws a remarkable light upon his disposition and exhibits the wonderful industry of which he was capable, even under circumstances that would have daunted many another. Suffering from the effects of travel and exposure to tropical heat, not in good health, and confined within the cabin of a little vessel of not more than 350 tons burden, he was indefatigable in describing his plants with the minutest accuracy, and in accumulating from them a vast store of facts and observations bearing on their structure and affinities, which did so much to lighten his subsequent labours on his arrival in England. Not only was he engaged in identifying and describing or naming his species anew, but he discussed questions of their relative adaptations to their surroundings, to temperature, etc., and the causes of the numerical proportions of the classes which he found.

On his return in 1805 his vast collections were added to the Australian plants then in England, which included the results of Sir Joseph Banks's own activity when sailing with Captain Cook, Dampier's plants at Oxford, and the accumulations of Nelson, Menzies, and other explorers, and Brown sat down to describe, classify, and comment on the whole mass, a task to which years were devoted.

His facilities for dealing with these plants, numbering something like 4200 species, were the greater in that he was made Librarian to the Linnean Society almost as soon as he had arrived in England. The resources of the Linnean collections were consequently at his disposal.

Of his work during the next five years Asa Gray has written in the following terms : "The whole herbaria of Sir Joseph Banks,

and the great collections which he made himself round the coast of Australia in Flinders's expedition and which he was able to investigate upon the spot in the four years devoted to the exploration, opportunely placed in Brown's hands as it were the vegetation of a new world, as rich as it was peculiar, just at the time, too, when the immortal work of Jussieu had begun to be appreciated, and the European and other ordinary forms of vegetation had begun to be understood in their natural relations. The new, various, and singular types which render the botany of New Holland so unlike all other, Mr. Brown had to compare among themselves, to unravel their intricacies with scarcely a clue to guide him, except that which his own genius enabled him to construct in the process of the research, and to bring them harmoniously into the general scheme of botanical natural alliance as then understood, and he was himself enabled to ascertain and display it. It was the wonderful sagacity and insight which he evinced in these investigations which, soon after his return from Australia, revealed the master mind in botanical science, and erelong gave him the position of almost unchallenged eminence which he retained as if without effort for more than half a century."

The first outcome of this task was the publication of the *Prodromus Floræ Novæ Hollandiæ et Insulæ Van Diemen*, which saw the light in 1810. It appeared in a single volume of 450 pages, but as it was styled vol. i. it was intended to be followed by another, most of the manuscript for which was already prepared. Though brought out while the Linnean system was still in the ascendency in England it was not arranged upon the artificial plan. There is much of the influence of De Jussieu and De Candolle in its construction, but the sequence of orders is different. Moreover, Brown found it impossible to allot to all the Australian plants places in the smaller groups of the French writers, and was led, therefore, to construct several new natural orders, of which he says with characteristic modesty that they "are not included in De Candolle's list." The work was marked by singular accuracy in detail, the language was precise and clear, and showed a powerful grip of the principles of classification as well as the possession of a wonderful power of observation. Brown took the opportunity to modify considerably some of the families of De Jussieu and De Candolle, though his work did not set out in any way to be a sketch of a new classification. The *Prodromus* dealt with 464 genera embracing upwards of 2000 species of which the majority were new to science.

Following the *Prodromus* Brown wrote an appendix to the account of Flinders's voyage, to which he gave the title of *General Remarks on the Botany of Terra Australis*. In this he made a new departure in botanical literature by discussing the influence of latitude and temperature in the tropical and temperate regions on the numerical proportions of the Monocotyledons and Dicotyledons. He also examined the geographical relations of the floras of the different parts of Australia and those of South Africa, South America, and New Zealand, in which he displayed great acumen.

This period of his life was marked by the production of papers which, though not of the scope of the *Prodromus*, were very remarkable in the insight which they showed, not only into the larger problems of classification, but into morphological and structural peculiarities of individual species. The first of these, a monograph of the Proteaceæ, was read before the Linnean Society in 1809, the year before the publication of the *Prodromus*. It was very typical of his subsequent style, dealing not only with the morphology of the species as bearing on their classification, but proceeding to treat very exhaustively of the various structural points which the plants exhibit and which, in the present day, would no doubt form the subject of a special memoir. In this paper on the Proteaceæ he opened with a consideration of their morphology and their systematic position, in which he incidentally showed that at that date he had not entirely abandoned the artificial system, for he paid it a tribute in acknowledging the assistance it gave by inculcating a minute inspection of the flower. He dealt also with the question of geographical distribution. But the paper is noteworthy as containing the first of those wonderful contributions to histology with which his name is associated: "That the *albumen* of seeds is merely that condensed portion of the liquor amnios which remains unabsorbed by the embryo, seems to me very satisfactorily established ; and as this fluid is in the early stage never wanting, all seeds may in one sense be said to have albumen ; but while in some tribes this unabsorbed part in the ripe seed many times exceeds the size of the embryo, so there are others in which not a vestige of it remains." If for "condensed portion of the liquor amnios" we now in our more complete knowledge substitute "cellular tissue of the endosperm," the passage might have been written to-day, giving as it does an account of a definite phase in the construction of the seed. The paper contains also a description of the pollen and its adaptation to the peculiarities of the stigma.

In the same year, 1809, Brown communicated to the Wernerian Society of Edinburgh a paper on the Apocyneæ of De Jussieu, from which he separated the Asclepiadeæ, advancing with great clearness arguments against their being united into one natural order. He dealt in a similar way with various points of the structure of the flower of Asclepias, histologically as well as morphologically.

We have in this treatment of important matters of intimate structure a feature of Brown's work which, from the point of view of the modern reader, is open to some criticism. Many of the discoveries associated with his name are to some extent difficult to trace, appearing almost parenthetically in the course of treatment of some larger theme. Several instances may be noted in his discussion of his Australian plants in the appendix to Flinders's *Voyage*. He analysed the structure of the plants of the various natural orders in such a way as to give himself an opportunity of dealing with difficult points in a manner which seems almost incidental. The elucidation of the true nature of the cyathium of the genus Euphorbia and the determination that the then so-called stamen is really a staminate flower are such points. Linnæus had called the cyathium a single flower, its involucrum a perianth ; and the staminate flowers stamens. In a single page of his work Brown demonstrated the inaccuracy of these assumptions and substituted for them the true morphological values as they are understood to-day. Many a less important matter has in modern times been expanded to the dimensions of a monograph. A similar comprehensive consideration of the morphology of the flower of the grasses, showing how it may be derived by suppression from the typical monocotyledonous trimerous flower, is very noteworthy and characteristic. We have here tersely presented the theory of its construction which obtained acceptance for many years and which in the opinion of many botanists of to-day is preferable to the more modern suggestions of bracteolar parts.

Attention may be called also to his analysis of the structure of Polygala and the determination of the character and limits of the Polygaleæ, which, while they were ignored by De Jussieu, were adopted by De Candolle and were incorporated by him in his conception of the structure of the group as set out in the first volume of his *Prodromus*.

The publication of these important works stamped Brown as the leading systematist of his time in England. They were followed by a number of papers of less value during the years 1811-14, which included a memoir on the fern Woodsia and descriptions of

various groups of plants cultivated in Kew Gardens. But the reputation which all this work brought him, opened the way to other investigations similar to those which found interpretation in the Australian *Prodromus*. The accumulations of plants collected in various scientific expeditions were referred to him for description and classification and a number of very important memoirs resulted, which, like that on the Australian flora, included important morphological discussions.

During the early part of this period, indeed, just about the time of the appearance of the *Prodromus*, an important change in Brown's life took place, which while it helped to determine his subsequent career, aided him materially in this systematic work. In 1810 the death took place of Jonas Dryander, who had been for several years Sir Joseph Banks's librarian, and had charge of his collections. Brown was appointed to succeed him, and was thenceforward the co-worker of Banks in the various spheres of his scientific activity, up to the time of his death in 1820.

The first of the collections with which Brown was concerned was a herbarium got together in Abyssinia during the years 1805 and 1810 by Henry Salt, F.R.S., and sent on his return to Sir Joseph Banks. Brown examined these plants and determined to what genera and species they should be ascribed, most of both groupings being new. The collection was arranged on the Linnean system at its publication in 1814. It was during this investigation that Brown detected a South African element in the Abyssinian flora. A much larger undertaking was the examination of the herbarium collected by Professor Christian Smith in Tackey's expedition to explore the Congo River in 1816. Brown discussed this on the same lines as he had adopted in the botanical appendix to Flinders's *Voyage*, arranging the plants on the natural system as amended by himself. In the course of his description of the flora he examined critically the question of geographical distribution of the plants, and particularly the means of dispersal of several forms which he held to have been imported into equinoctial Africa. He traced in various forms such anatomical and physiological peculiarities as would lend themselves to transport, dealing under the latter head especially with the power of resisting the action of salt water, and of passing uninjured through the alimentary canal of birds. His investigations into this question were suggested to him by the relative number of species of Dicotyledons and Monocotyledons, which he found amongst the plants of the herbarium.

A third noteworthy collection was that made in Melville Island in 1820 by the expedition under Captain Parry. Brown prepared a systematic list of the plants, giving very fully in Latin the characters and descriptions of the new or only imperfectly known genera and species.

In 1825 he had submitted to him the plants collected in North Africa by Dr. Oudney and his companions. The observations he made upon the structure and affinities of the more remarkable of them appeared in 1826. This memoir is remarkable not so much for the mass of material dealt with as for the critical examination of the morphology of many of the natural orders and the able discussion of difficult points of structure. Among them we may call attention especially to the Cruciferæ, a group to which he devoted many pages, discussing the structure of the flower, fruit, and seed throughout the order with singular clearness and felicity. His treatment of the Capparideæ was almost as exhaustive, while his analysis of the structure of the flower of Reseda and the delimitation of the order Resedaceæ were models of logical argument. Differing from the French school which was supported in England by Lindley, Brown clearly defined the order, and gave reasons for detaching from it the genera that had been included in it in a new order, *Datisceæ.* His treatment of the Leguminosæ was equally skilful ; his discussion of the variation in the numbers of the stamens and carpels, and their relative positions leaves nothing to be desired.

Though these were the principal collections with which Brown was concerned they were by no means the only ones. He was occupied also with the botanical results of Captain Ross's voyage to Baffin's Bay, Captain Scoresby's expedition to Spitzbergen, Captain Stirling's examination of the Swan River district, and Captain Start's expedition into Central Australia, all of which added valuable material to our knowledge.

Of the more strictly taxonomic work which occupied him during these years mention should be made of his memoir on the Compositæ, which he communicated to the Linnean Society in 1816.

In the first part of this paper he was occupied by a discussion of the work of M. Henri Cassini and the relative parts played by himself and this author in elucidating the intimate structure of the flowers of this order, but he passed on to give a masterly exposition of their structure and of the construction and behaviour of the inflorescence, to which for the first time he applied the term *capitulum.* He also dealt with some of the problems of pollina-

tion, particularly protandry and protogyny, as well as with some other of the more obscure points.

The equable tenor of his life was disturbed in 1819 by the offer of the professorship of botany in the University of Edinburgh, vacant through the death of Dr. Rutherford. No doubt these proposals caused him some anxiety. Botany at Edinburgh was in a very languishing condition, Rutherford having done little or nothing to favour the study, and certainly nothing to advance the subject. It would have made a great change in Brown's own work, for it would have involved the abandonment of his steady but placid activity in the study and the herbarium, and the assertion of himself in the lecture room. We can hardly imagine him pursuing the course of inactivity that had characterised Rutherford almost since the death of Hope. The change of life and work did not appeal to him, and he declined the appointment. Possibly this course involved the abandonment of considerable influence in the botanical world, but it enabled him to retain his position at the centre of things in London, to play a great part in the scientific gatherings in the metropolis, and to maintain and develop still further his career in connection with the British Museum and Kew Gardens. Nor is it clear that he would have been so successful at Edinburgh ; he was never a propagandist, and much preferred quiet unobtrusive work, speaking rather by means of his writings, and in that way advancing botanical science. Though the progress of the natural system of classification was aided in England more by him than by any other botanist, it was not by public appeal or by eloquent advocacy. His works let the Linnean system severely alone ; he advanced the rival scheme by adopting it in his writings and basing so much important work upon it that even its opponents were compelled to adopt it. Quietly and unobtrusively he sapped the foundation of the Linnean system, never leading a violent attack against it. Indeed, he ignored it more than he opposed it, bringing into strong relief the superiority of the natural system. His position at the Linnean Society, and his access to the treasures of Banks's collections enabled him to develop his views on affinities based on structure as he could not have done elsewhere, and to this we may trace those masterly publications which so enhanced his reputation. These would have been seriously interfered with by his removal to Edinburgh.

But another consideration may perhaps have influenced him. In his youth he had been an active explorer, and in his Australian

expedition he had shown energy and application even to the sacrifice of health in the pursuit of botanical research. The hardships and fatigues then encountered had engendered a distaste for this side of botanical work ; he undertook no more of it, and indeed was inclined to discourage young aspirants from embarking on similar labours. So that the sedentary side of the study had come to appeal to him more and more, and tended to develop in him the disinclination for publishing his discoveries that many have detected in his later life. He appeared satisfied with the position he had gained and the honours his works had brought him, for he had attained the distinction of the Fellowship of the Royal Society in 1811, and was recognised as the leading representative of botany in England. Another reason for his action lay in his relationship to Banks, to whom he owed so much and with whom he had worked so long. No doubt sentimental considerations had their influence, for Sir Joseph was now well advanced in years. He was almost immediately invited to succeed Graham at Glasgow, but the same considerations stood in the way of his acceptance of this Chair also. So he refused to go to either University, and in so doing incidentally led to the appearance in academic life of the elder Hooker to whom later Kew Gardens came to owe so much.

In 1820 Sir Joseph Banks died, and great changes came over the centre of scientific activity in Soho Square. He left the library and the collections which represented so much activity and the work of so many ardent naturalists to Robert Brown for his life, stipulating that when he should die they should be transferred to the British Museum. Brown resigned the Librarianship of the Linnean Society in the same year.

In 1827 Brown assented to the transfer of the Banksian library and collections to the British Museum, and he was made Keeper of the Botanical Department there. The transfer was in conformity with a provision in Banks's will.

His subsequent life was spent on much the same lines as the years at Soho. A record of placid persevering work, and the gradual accumulation of further honours are the main features it presents. In 1832 Oxford gave him the honorary degree of D.C.L.; in the next year he was made a Foreign Associate of the Academy of Sciences of the Institute of France. He was frequently on the Council of the Royal Society, and was awarded the Copley Medal in 1839. During the administration of Sir Robert Peel he received a pension of £200 a year from the Civil List, which

enabled him to continue his work untroubled by any pecuniary difficulty till his death. Indeed, it is doubtful whether the comfort of his later years was without its influence in making him somewhat careless about publishing the remarkable discoveries which he continued to make. Some time before his death the King of Prussia decorated him with the cross of the highest Prussian civil order, "Pour le mérite."

He was President of the Linnean Society for the four years 1849-53. He passed away at the advanced age of eighty-four, dying peacefully in his library on June 10, 1858.

CHAPTER XXXIV

THE LIFE OF ROBERT BROWN—*continued*

Brown's Anatomical Researches

THE publications to which reference has been made represent only one side of Brown's activity. They have been advanced chiefly to prepare us for a consideration of his influence on the revival of the natural system in England. But there is a large section of both his earlier and his later work, which while in some respects it bears upon the same side of botanical science, is even more noteworthy as helping on the development of our knowledge of the minute structure of both the vegetative and the reproductive organs of the plant. It led, moreover, directly to the greatest contribution made to systematic botany by an Englishman since the death of Ray, the recognition of the naked condition of the ovules in the Cycadeæ and the Coniferæ, with the result of the formation of the great division of the Gymnosperms.

Brown's writings on these lines hardly marked a difference in method. As we have already noticed, histological and morphological questions were often discussed in a sort of parenthetical fashion in the course of his larger systematic papers, as if they were suddenly presented to him in the course of these other researches, and he felt unable to pass them by unsolved, incorporating accordingly his observations on them in the larger work. The examination of minute detail was, indeed, a feature of his researches throughout his life. After his taking over the care of the Banksian collections he gave more attention to this side of botany, and it was during his subsequent years that his most important contributions to it were made.

His first paper, avowedly on a histological subject, was quite early. It was an examination of the parts of fructification in the group of the Mosses, and was read to the Linnean Society in 1809. He threw it into the form of a criticism of the views put forward by Beauvois, who thought he recognised organs of both sexes in the interior of the capsule. The one he called pollen, which were the spores, he saw lying " just under the skin " ; the other he called " seeds," and spoke of their presence in the

substance of what we now call the columella. Brown denied the existence of these "seeds" in the interior, giving his support to the views of the structure which had been brought forward by Hedwig, and criticising with some severity Beauvois's methods of dissection. He took Hedwig's view, however, that the spores are seeds, and discussed the region of their formation in various species. The keenness of his observation was remarkable in his description of the features of the columella and peristome, but there is little evidence that he understood the structure of the capsule.

He read to the Linnean Society in 1813 and 1816 two memoirs on some abnormalities in the structure of fruits and seeds, which aided materially to define both, and to clear up the confusion that had existed between seeds and small fruits of the achene type. In the paper he showed how frequently the structure of the fruit is apparently altered by the process of abortion. He also described for the first time the vivipary of the Mangroves.

It was to his pen in 1820 that we owe the description of the curious parasite of Sumatra, *Rafflesia Arnoldi*, discovered by Sir Stamford Raffles while on a journey into the interior of the island, and sent home by him to Sir Joseph Banks. The large flower described in minute detail by Brown, and illustrated very fully by Francis Bauer, proved to be staminate only; it was not till fourteen years later that the story was completed by the discovery and description of the pistillate flower and its comparison with *Hydnora africana*, a comparison which went far to elucidate the structure of both. Hydnora was drawn and painted by Ferdinand Bauer, so that both brothers contributed to our knowledge of these curious parasites. From a further comparison with Brugmannsia and Cytinus, Brown was able to constitute and subdivide the order Rafflesiaceæ.

His curious plan of treating of great morphological problems by way of parenthesis or appendix to memoirs on particular plants or floras was illustrated very remarkably in a paper which he read before the Linnean Society in 1825. It set out to deal with the individual peculiarities and systematic position of a liliaceous plant, Kingia, which he observed in 1801 during his Australian explorations, and which was re-discovered by Captain King in 1822. The genus presents certain noteworthy features, but he only devoted to its description four pages out of twenty-six. He added two appendices, each of which is much more remarkable than his main thesis. The first of these was a careful

essay on the structure of the ovule, which he described with a completeness that even to-day leaves little to be desired. The nucellus, or as Brown called it, the nucleus, with its two integuments covering it completely, except at the apex, the open foramen or micropyle between them, and the relations between all these parts, with the peculiarities each presents, were all set out clearly and distinctly. He drew attention to the position of the embryo in the seed, and came to the important conclusion that impregnation takes place through the micropyle. The vascular supply to the ovule, the raphe in which the vessels pass, and the function they fulfil were described; the occasional presence of an aril was noticed, and its morphology explained; the embryo in its "additional coat" the "Amnios," the behaviour of the latter with its contents, the formation of albumen, both in the amnios, and in some cases in the cells of the nucellus—all were described and illustrated. Save, indeed, for small differences of terminology, Brown described the structure of the seed and its development almost as we know it to-day.

The second appendix to this paper was one of the most important contributions its author made to science, being the discussion of the morphology of the female flower (so called) in the groups of the Cycadeæ and the Coniferæ, which led directly to the recognition of the group of the Gymnosperms. Anatomical considerations based on the structure of sundry orthotropous ovules occurring in the Cistaceæ, led him to the opinion that in some cases an ovarium is wanting, or is so imperfect that the pollen actually reaches the ovule. He then was led to think this the case in Cycadeæ and Coniferæ, and in the genera Ephedra and Gnetum. Brown proceeded in his usual cautious manner to test the validity of the hypothesis. He set forth dispassionately the other views of the morphology that had been advanced, and brought against them an elaborate argument, dealing in detail with the objections to his view, and showing that the latter only is consistent with the structure. He reviewed in this connection the speculations of De Jussieu, Linnæus, Mirbel, Schoubert, and other writers who had made other proposals as to the homologies, which, being based on the construction of the flower of the Angiosperm, he strove to refute. He was, however, not clear in his opinion as to the true homologies between these ovules and the staminal arrangements of the groups under discussion.

Brown in this memoir clearly established the gymnospermous character, and so defined a group of almost as great magnitude

as Ray's great classes of Monocotyledons and Dicotyledons. The definition was not complete at this stage, but so far as he went he cleared the path for his subsequent investigations into the peculiarities of structure which characterise the ovule and the seed, the whole of his work preparing the way for the researches of Hofmeister, who first showed the true homologies of the latter.

A second series of researches upon this subject was commenced almost at once on the completion of the first paper, but they were not published for many years. It is rather difficult to give a reason for this course ; it became rather a habit with the illustrious author in his later years to rest content with making observations, and to put off, in somewhat dilatory fashion, the less interesting work of preparing them for the press. The work, begun in 1826, was communicated to the world at the meeting of the British Association in 1834, and was finally published in the *Annales des Sciences Naturelles* in 1843. After showing that polyembryony, observed by him in Cycas in 1802, is of very common occurrence in the Coniferæ, and is almost universal in Cycadeæ, he described the structure, and to a large extent the development, of the embryo in these groups.

Dealing with the structure of the ovule he ascertained that prior to impregnation there is developed within the nucellus an "Amnios," which is a solid uniform substance. We have here clearly indicated the megaspore with its included endosperm or prothallus, or in the language of a few years ago the "albumen formed before fertilisation." In this solid uniform substance he noted at a little later stage a number of areolæ, or portions destined for the production of the embryos, which are situated near the apex, and are arranged in a circular series. They were three to six in number, and each of them could be observed later to be connected with the apex by minute points of a deeper colour. As they got older the remains of these embryoniferous areolæ exhibited a filament or funiculus consisting of several elongated cells or vessels, with or without transverse septa. These filaments often branched, each branch terminating in an embryo rudiment. The lateral branches usually consisted of a single elongated cell, while the terminal one was generally formed of several. Here we have a picture of the archegonia, or "corpuscula," each giving rise to an embryo with a long suspensor.

Incidentally we may read in this paper notes of the occurrence of the embryosac or megaspore in Gymnosperms as well as in Angiosperms ; of the different time of development of endosperm

within it; of the occurrence of archegonia in the former group, and of the necessary occurrence of polyembryony. From the identity of these histological features in Cycadeæ and Coniferæ, Brown drew definite conclusions as to their close affinity, and marked them off with some emphasis from the larger group of the flowering plants. He said: "With regard to *Cycadeæ*, whatever opinion may be adopted as to the precise mode of action of the pollen in that family, it is certain that the mere enlargement of the fruit, the consolidation of albumen and the complete formation of the corpuscula in its apex are wholly independent of male influence, as I have proved in cases where pollen could not have been applied."

Brown has often been credited with the discovery of the archegonia or corpuscula of the Gymnosperms. In this paper he certainly described them more fully than any previous writer, and associated them, by microscopic observations, with the embryos, but he did not claim that he was the first to see them. Indeed, he gave that credit to "the late Aubert du Petit Thouars," who in a dissertation on the structure and affinities of *Cycas*, published in 1804, "distinctly notices . . . the corpuscula within the apex of the albumen, into which corpuscula he hazards the conjecture that the grains of pollen enter and become the future embryos." On the other hand, he referred to "my areolæ or corpuscula," and claimed to have carried the subject much further than du Petit Thouars, for he traced their development in the endosperm, and showed that in Pinus they are not formed till the spring or summer of the year after the appearance of the flower.

Another very valuable contribution made by Brown to botanical science was his examination of the morphology and histology of the flowers of the Orchidaceæ and Asclepiadaceæ, which he carried out in 1831 and 1832. There had been for many years some obscurity in the minds of the leading botanists on the question of the fertilisation of the flowers of the former group, the method of pollination being obscure; the process itself, indeed, being according to some, improbable. Those who held to the idea of pollination were puzzled by the occurrence of the pollinia, and could not agree as to what it was what they called the fecundating element. Francis Bauer, in his wonderful illustrations of orchideous plants published in 1830, had put forward the view that something passes from the pollinium down the stalk or caudicle to which the latter is attached, and makes its way into a stigmatic channel through the gland which terminates the stalk. To this problem

Brown first brought his critical acumen, and after discussing Bauer's evidence unfavourably, brought forward his own investigations, which, however, he had not confined to that point, but extended to the whole of the flower.

He first established the now accepted view of the morphology of the flower, and showed how it belongs to the accepted monocotyledonous trimerous type with biseriate perianth and stamens, pointing out what represent the rudimentary lateral antepetalous stamens, and showing how this theory only explains the structure of *Cypripedium*. This he claimed to have set out long before in the *Prodromus* of 1810, though he had changed his views upon some points in the homologies.

He examined the conditions of pollination, and determined that the whole pollen mass must be applied to the stigma by insect aid, also that a single pollinium may pollinate several flowers in succession. He noticed that the genus *Ophrys* is an exception to the general rule, and thought that the fanciful resemblance of the flowers of its several species to particular insects is to deter rather than to attract their visits.

He worked out the structure of the ovule and its development, with the changes which supervene after fertilisation. He distinguished the formation of the suspensor and the embryo, together with the subsequent elongation of the former.

He was the first to detect the formation of the pollen tubes in this family, but he was not clear as to their normal behaviour, though he traced their intra-ovarian course as far as the placentæ. He recognised certain tubes, which he did not see to be directly continuous with them, in *Orchis morio* and several other species, and traced these latter to the openings or micropyles of the ovules. He thought they were developed from the pollen tubes, perhaps generated by them, and he named them mucous tubes. He spoke of the growth of the pollen tube as a protrusion of the inner membrane of the pollen grain, which he considered a vital action exerted by the application of an external stimulus, the contact with the surface of the stigma. In its growth he held it to be nourished either by its own reserve products, or by absorption of nutrient material from the style. He found that a single pollinium can fertilise several ovules, or perhaps can pollinate several flowers, and determined that the time of the action of the pollen can be detected by the withering of the stigma and decay of the style, followed by the enlargement of the ovary.

It is a little strange that so critical an observer did not recognise

that the formation of the pollen tube is the sign of a process of *germination* of the pollen grain.

His work on the flower of Asclepias was concerned mainly with the structure and behaviour of the pollinium, which he proved to be cellular in all stages. He helped to elucidate the problem of pollination by finding pollinia in the stigmatic grooves of the column, and he traced the production of the pollen tubes. The pollinia give rise to the latter only on the convex sides of the mass; thence they enter the styles and pass down to the placentæ. He traced the pollen tubes to the ovules, which he thought to be without any micropyle, and he considered that they bore their way into the ovular tissue. He saw that the tubes contain granules of more than one kind, but thought they were nutritive and not fecundating.

At the end of the memoir on the Orchidaceæ another important histological discovery was unobtrusively announced. This was the fact of the occurrence of the nucleus of the vegetable cell, a discovery whose importance he did not at first realise. It was announced in the following terms: "I shall conclude my observations on Orchideæ with a notice of some points of their general structure, which chiefly relate to the cellular tissue. In each cell of the epidermis of a great part of this family, especially of those with membranaceous leaves, a single circular areola, generally somewhat more opaque than the membrane of the cell, is observable. This areola, which is more or less distinctly granular, is slightly convex, and although it seems to be on the surface is in reality covered by the outer lamina of the cell. There is no regularity as to its place in the cell, it is not unfrequently, however, central or nearly so. . . . This areola, or nucleus of the cell, as perhaps it might be termed, is not confined to the epidermis, being also found . . . in the parenchyma or internal cells of the tissue. . . . In the compressed cells of the epidermis the nucleus is in a corresponding degree flattened, but in the internal tissue it is often nearly spherical, more or less firmly adhering to one of the walls and projecting into the cavity of the cell."

This nucleus it will be seen was only an interesting peculiarity to Brown. He had, of course, no inkling of its importance—indeed, he was not sure of its universal occurrence. "This nucleus of the cell is not confined to Orchideæ, but is equally manifest in many other Monocotyledonous families; and I have even found it, hitherto however in very few cases, in the epidermis of Dicotyledonous plants."

It may be mentioned that while studying this feature of the cell he discovered the phenomenon of cyclosis in the staminal hairs of Tradescantia, though he formed no opinion of its importance. His comment on it is confined to a statement of its interest as a microscopic object.

In some investigations made by Brown on the process of fertilisation following pollination, during the year 1827 he discovered that curious phenomenon named after him, viz. the Brownian movement. Working on Needham's hypothesis in opposition to the view of Grew and Linnæus that impregnation is due to an "aura," and ascribing it to the transference of particles emitted by pollen grains bursting on the stigma, he was trying to trace the behaviour of such particles when suspended in water on a microscope slide. He found them to be from $\frac{1}{4000}$ to $\frac{1}{5000}$ of an inch in diameter, and to be in active motion, twisting and oscillating violently, whether they were in water or in the substance of a transparent grain. At first he associated the movement with vitality, but soon found any similar small particles, under the same conditions, behaved in the same way. Hence he held it to be a purely mechanical molecular movement.

Among his minor papers may be mentioned a description of a silicified fossil to which he gave the name *Triplosporites*, and which he held to be closely related to Lepidostrobus. This was, however, a field in which he made few observations. He was always strongly attached to it, however, and with a view to its prosecution he made an extensive collection of fossil woods, which he bequeathed to the British Museum.

It would be difficult to exaggerate the importance of the work done by Brown in almost all the departments of botanical science, or the influence he wielded both at home and on the Continent of Europe. Gray calls attention to the fact that "next to Humboldt his name adorned the list of a greater number of scientific societies than did that of any other naturalist or philosopher. Humboldt himself called him 'Botanicorum facile Princeps' and the universal consent of botanists confirmed the title." He rendered incalculable service to systematic botany by increasing knowledge of genera and species brought from almost every part of the world, bringing to bear upon them unrivalled powers of detailed observation, wonderful skill in description, and marvellous faculties of critical diagnosis and discrimination. In considering questions of lassification he brought into prominence the idea of development s a factor, anticipating then the modern views which came into

vogue after the epoch-making work of Darwin. Sachs says of him: "He succeeded better than any of his predecessors in separating purely morphological and systematically valuable relations of organisation from the physiological adaptations of organs. While the majority of systematists surrendered themselves to the guidance of a blind feeling in the discovery of affinities, their correct determinations being the accidental result of instinct and unconscious operations of the understanding, Brown endeavoured to give an account to himself in every case of the reasons why he took this or that view of the relationships which he determined; from what was already established and indubitable he gathered the value of certain marks, in order to obtain rules for the determination of unknown relationships. In this way he discovered also, that marks, which are of great value for classification within the limits of certain groups of affinity, may possibly prove to be valueless in other divisions. Thus Robert Brown in his numerous monographs supplied the model, by which others might be guided in further applying and completing the method of the natural system."

With all his power of critical examination, his keen judgment and acumen, and his unexampled opportunities, it has often been felt that Brown did not make himself so prominent a figure as he might have done, nor did he take the place that he might easily have claimed in the rank of systematists. Many men of greatly inferior parts brought forward complete plans of classification—indeed, no fewer than twenty-four systems made their appearance during his life-time. No man of the time was more suited than he to prepare a *Genera Plantarum;* probably no one had equal facilities. He preferred to work unobtrusively and to influence the development of the natural system modestly by monograph and memoir rather than to appear as an active propagandist. His preference for the quiet of the library and the herbarium, however, consorted with modesty of temperament, was not without its drawbacks, for combined with the easy circumstances of his later years it induced a degree of something like indolence which has left much cause for regret. Possibly this may account for the long delay in completing the research which was certainly not the least important of his many labours, the elucidation of the position of the Gymnosperms, which, with all his brilliant results, he left for completion to the later activities of Hofmeister. But this tendency to leisurely publication was a mark of something beside indolence. All his work bears signs of matured thought and careful

reasoning. To quote again from Asa Gray: "Brown delighted to rise from a special case to high and wide generalisation, and was apt to draw most important and always irresistible conclusions from small selected data, or particular points of structure, which to ordinary apprehension would appear wholly inadequate to the purpose. He had unequalled skill in finding decisive instances. So all his discoveries, so simply and quietly announced, and all his notes and observations, sedulously reduced to the briefest expression, are fertile far beyond the reader's expectation. Cautious to excess, never suggesting a theory until he had thoroughly weighed all the available objections to it, and never propounding a view which he did not know how to prove, perhaps no naturalist ever taught so much in writing so little, or made so few statements that had to be recalled or even recast." His mind was at once scrupulous and cautious, his reasoning clear and profound. He was very retiring in his disposition, carrying modesty almost to excess. Perhaps as a natural conclusion from this he was very careful to do justice to other workers whom he had to criticise, and to avoid any appearance of arrogating to himself more than he was fairly entitled to. A somewhat cold and distant manner hid a geniality of feeling and disguised the pure benevolence of his disposition. His accuracy of judgment was surpassed only by his unswerving devotion to truth. He possessed a keen sense of humour, and a peculiar dry wit, and was always a genial companion and friend, as well as a leader of scientific thought.

CHAPTER XXXV

THE LIFE OF ROBERT BROWN—*continued*

Brown's influence on Taxonomy

But we must turn to consider in more detail how his influence was brought to bear upon the great question of the revival of the natural system of classification in England. What was the condition of things in the early part of the nineteenth century? Though much had been done in Brown's earlier years and even before that time, in the way of collecting and routing, the work was almost as much geographical as botanical. No actual progress in taxonomy was made, and as a consequence a reaction set in. A healthy discontent with the Linnean system sprang up—its finality was recognised as utterly unscientific, and it was felt to be a hindrance to further investigation. Before it had driven the natural system from the field a certain progress had been made with the latter. Ray had laid down broad lines so far as flowering plants were concerned, when he made the first great distinction between Monocotyledons and Dicotyledons. He had gone a little further, by suggesting various groups within these classes. Though as a whole his sketch was manifestly incomplete, many of his families were very natural, and indeed have in the main persisted, while others were entirely wrong. His division of plants into trees, shrubs, and herbs proved entirely unsatisfactory. At about the same period Tournefort had elaborated genera, and a little later Linnæus had given precision to the idea of species. Moreover, the lines of advance had been indicated by Ray when in his *Historia Plantarum* he defined a natural system to be that *which neither brings together dissimilar species, nor separates those which are nearly allied.* Many continental writers had made contributions to the subject, but mainly on the lines of Cæsalpino and his school.

Such was the state of classification which came before the mind of De Jussieu, and such the basis on which he began to work. Though his proposals saw the light in France they must be mentioned here as the English revival was originally based upon them. They took shape in the *Genera Plantarum* which he published in 1789.

His primary division was into Acotyledons, Monocotyledons, and Dicotyledons. Here he followed Linnæus, who had so far developed the idea of Ray as to raise the Imperfectæ of the latter into a group co-ordinate with each of the others instead of making it co-ordinate with all the flowering plants taken together. The name was evidently derived from Ray's nomenclature, and unfortunately so, as the point on which stress was laid in defining it was the supposed absence of an embryo and not the possession of one devoid of cotyledons. Linnæus had substituted Polycotyledons for Dicotyledons, but De Jussieu went back to the older term.

De Jussieu's Acotyledons embraced all the non-flowering plants, afterwards called Cryptogams, together with the Naiadaceæ. He divided the Monocotyledons into three classes, and the Dicotyledons into eleven more, using the position of the stamens, and the perianth with relation to the axis of the flower and the position of the ovary as distinguishing characters in forming them. By these means he formed in all fifteen classes, and these he subdivided in various ways, recognising a hundred "natural orders," groups of genera now for the first time described as possessing distinctive characters.

De Jussieu's system existed side by side with that of Linnæus for a great part of the period to which our last chapter referred, but it made but little progress in England during all that time. It was not till 1821 that it could be said to have come into favour, but it was then introduced into the Chelsea Garden and ordered to be taught to the students side by side with the other, as we shall see later, and from that date onwards we may trace its gradual adoption.

De Jussieu's proposals represented thus the greatest development of the natural system up to the time when Brown wrote his *Prodromus Novæ Hollandiæ.* As we have seen, he arranged this work partly upon them, but he omitted the fifteen classes, which he thought artificial—as they undoubtedly were. He also changed the sequence of the natural orders and added several others to De Jussieu's list.

We see in these suggestions of De Jussieu and Brown what was a very great improvement, the idea of a more complete gradation, the introduction of the grouping of genera into orders, and of orders into larger groups, at first called classes, so that a large division like the Dicotyledons was not merely a collection of small families. The idea was only in its infancy, however. De Jussieu

did little to fill up the gaps, for his fifteen classes were but artificial; nothing was properly arranged between the largest groups and the natural orders. Nor were the natural orders arranged with a true perception of relationship and proportion. The whole series was made to culminate in the Coniferæ. With the large accessions in number of both genera and species that were brought to light by Brown's labours, the insufficiency of the proposals became painfully apparent. More systematic subdivision was imperatively called for, and in this respect Brown was a pioneer. Later systems, to which we shall allude in their turn, show attempts to find satisfactory groups attended with greater or less success.

But when we try to grasp the principles on which the natural system so far was founded, we are surprised to find how little real advance they showed upon Ray's position. As we have seen he had set out the objects of the system in the *Historia*. But in the minds of Ray and of his successors alike there was as a fundamental principle the recognition of the dogma of a special creation of all true species. Indeed a few botanists felt that there could be but one natural system, that which must be based upon such special creation and which by its very nature must be invariable, the only difficulty being to discover it. Fixity of species was the great stumbling-block, a strange circumstance indeed, after the experiments made during the eighteenth century on crossing and hybridisation. The result of the theory of special creation was that there was no clue to real relationship—only similarity of form and structure could be detected. Hence classifying was like arranging specimens in a museum, resemblance took the place appropriate to relationship. The process of classification was much like wandering in a wilderness till Darwin and Wallace supplied the longed-for clue, by introducing the factors of variation and descent, and so supplied for investigation a scientific basis. The old difficulty furnished Linnæus with the idea that the arrangement of plants must resemble the mapping out of countries in a continent, rather than the construction of a lineal series. The only plan that seemed to offer possibilities of success was that of grouping a few species round a so-called "type," but there was no clear idea of the meaning of the type, nor of its relation to the group that was gathered round it. Even the type was arbitrarily selected; indeed, it was often nothing more than a sort of Platonic idea, not necessarily real—a sort of abstraction rather, which enabled one to find points of contact with other groups, suggesting, rather than indicating, some sort of relationship

to it and hence to each other. There can be little wonder that matters remained unsatisfactory till descent came into view.

But to return to Brown's influence upon the framing and development of the natural system: how great this was may be gathered from the words of Sachs: "Robert Brown in England led the way back from the pursuit of fantastic will-of-the-wisps to the observation of actual fact. Instead of evolving schemes out of their own internal consciousness as to how plants ought to be constructed, he endeavoured to discover by the study of development and more particularly of embryogeny how they actually were constructed." There is no doubt that he widened the basis of knowledge by the great precision of description which, like Linnæus, he possessed in very great degree, and which led him to establish diagnostic marks of new genera and species presented to him in the exotic floras which were sent to him from all quarters of the globe and to group them into new natural orders. He was especially successful in his delimitations of the latter, apparently regarding the construction of such families as the basis of a natural system. At the same time he laid considerable stress on the importance of grouping these orders together in such a way as to show several clearly defined subdivisions of the larger classes, a plan which led to the conception of the "Cohorts" so generally adopted in the more recent systems propounded. It may seem a little strange that with these ideas he abandoned De Jussieu's fifteen classes; to them, however, his objection was based on the artificiality of the lines of cleavage. In determining to his own satisfaction the limits of his groups he took into account and made of the first importance the stages of development of the individual plant and brought into great prominence the study of embryogeny. In this matter he stood alone among the systematists of his time. Though not possessed of the idea of evolution by natural selection, which only appeared with Darwin, he yet seemed to have an inkling of the direction in which research should run, though it might be rather a groping in the dark. In drawing up his diagnoses he took a much broader view than his predecessors, often insisting on points of histological detail as giving evidence of relationship, and so suggesting a line of affinity developed in late years by Radlkofer and Solereder. But the most important advance which is associated with his name was the delimitation of the great group of the Gymnosperms as distinguishable from other flowering plants. In this we see the result of the application of the principles which underlay his work. It is true that he did not antici-

pate entirely the position which to-day is accorded to the group—this was not realised till long after his work had been followed and completed by Hofmeister. It is true also that the group was for a long time held to be a subdivision of the Dicotyledons, a mistake apparently arising from an inaccurate estimate of the value of the structure of the stem and of the process of secondary thickening. Still the discovery remains—a discovery which will always rank in importance with Ray's separation of Monocotyledons from Dicotyledons.

Brown did a further service in his later years by combating an idea which came into prominence under the advocacy of Lindley, that in addition to the morphology and histology of plants, all sound principles of classification should take into account questions of physiology. To this point we shall return, but for the moment we may point out that its adoption would lead to almost intolerable confusion.

In his writings bearing on the revival of the natural system, Brown was never polemical. Indeed, in his earlier work he accepted the Linnean system as he found it, and used it side by side with the other in describing new genera and species. In his introduction to his monograph on the Proteaceæ, written in 1809, he says: "The Linnean system of botany, though confessedly artificial, has not only contributed more than all others to facilitate the knowledge of species, but by constantly directing the attention to those essential parts of the flower on which it is founded, has made us acquainted with more of their important modifications than we probably should have known, had it not been generally adopted, and has thus laid a more solid foundation for the establishment of a natural arrangement, the superior importance of which no one has been more fully impressed with than Linnæus himself." But he served the cause of progress by bringing forward unobtrusively, yet none the less certainly, the superiority of the natural system in arranging as he did the various floras he examined, by contributing to botanical literature important monographs giving descriptions of separate families, by comparing those families with each other, and by arranging them on the lines of general rather than special resemblance. He thus rather ignored the Linnean system and showed that there was in course of actual development, a better way. His characteristic caution was apparent in the controversy; a man of reflection, and a worker in the study or the herbarium, he could not become an active propagandist.

CHAPTER XXXVI

JOHN LINDLEY AND THE VEGETABLE KINGDOM

But while Brown was unobtrusively working for the recognition of the natural system in England, progress on a very considerable scale was made in France and Switzerland, where the proposals of De Jussieu were first modified and then superseded by those of De Candolle, perhaps the greatest systematist who had appeared. His system, indeed, served as the basis of those which appeared in such numbers during the first half of the nineteenth century, and was particularly the foundation of the proposals of Lindley, and later of those of Bentham and Hooker.

We must briefly allude to the De Candollean system on account of the influence it exerted upon our own taxonomists. It was based on a clear theory, that morphology must be the basis of the work, and that physiological conceptions are of comparatively little value. This was put forward by A. Pyrame de Candolle in his first sketch of 1815, and it was emphasised again in his second edition of 1819. He showed, too, that while it is a fundamental principle its application may be obscured by the occurrence of abortion, degeneration, and unions of various kinds, and that these must be taken into consideration in determining the true symmetry of plants. In the introduction of these conceptions he really dealt a blow at the current views of the constancy of species, in which the phenomena of abortion and degeneration had no place, pointing out how abortion in one part may be correlated with increased growth in another.

De Candolle's first sketch was the following :—

1.	Dicotyledons;	polypetalous and hypogynous
2.	,,	polypetalous and perigynous
3.	,,	monopetalous and perigynous
4.	,,	monopetalous and hypogynous
5.	,,	apetalous or with a single perianth
6.	Monocotyledons;	phænogamous
7.	,,	cryptogamous
8.	Acotyledons;	leafy and sexual
9.	,,	leafless and without any known sexes

It will be seen that he followed De Jussieu in his formation of three great classes based upon the cotyledons, and to some extent

in his divisions of the first class. He went astray in his second class in which he grouped together the Monocotyledons and the Vascular Cryptogams.

In the 1819 scheme he took another retrograde step, by introducing the vegetative characters of the stem as alternative to the structure of the embryo. The outlines of this plan were the following :—

1. *Vascular or Cotyledonous Plants*:—
   - α. Exogens or Dicotyledons
     - (1) Perianth Double
       - (*a*) Thalamifloræ
       - (*b*) Calycifloræ
       - (*c*) Corollifloræ
     - (2) Monochlamydeæ
   - β. Endogens or Monocotyledons
     - (1) Phanerogams
     - (2) Cryptogams
2. *Cellular or Acotyledonous Plants*:—
   - α. Foliaceæ, having leaf-like expansions
   - β. Aphyllæ, not having leaf-like expansions

We see here the tendency to substitute vegetative for embryonic characters in the chief classes, a change to be deprecated in the light of Brown's subsequent discoveries as hindering the recognition of the true position of the Gymnosperms.

De Candolle himself admitted the artificial character of the groupings within these larger classes, based as they were mainly on unions of the parts of the flower, partly physiological in their origin. In the scheme of 1819 he proposed the grouping of families into cohorts within the limits of his smaller divisions. These were, however, not very satisfactory and were abandoned by his son in his own proposals of 1844.

Comparison of the proposals of De Candolle with those of De Jussieu show that the new scheme was a great advance upon the old. De Candolle advanced it still further by the series of monographs of families which he contributed to literature and by the projection and partial completion of the *Prodromus* which bears his name—a work which took an even more conspicuous place than had the *Pinax* of Bauhin more than 200 years before.

The work of De Candolle in Switzerland was in the main contemporary with that of Brown in England. Both exerted considerable influence on the progress of the natural system, though Brown, as we have seen, took no active part in propagandism. Far otherwise was it with another English botanist, John Lindley,

a colleague of Brown during part of his career, but an ardent advocate of the new reforms which he laboured assiduously to shape.

Lindley was of humble parentage, his father being a nurseryman who lived at Catton near Norwich. He was born there in 1799 and was educated at the grammar school at Norwich till he was sixteen years of age. On leaving school he went to assist his father in his business and remained with him for about four years. One of the interesting episodes of his early life was the friendship he formed with the elder Hooker who was his schoolfellow, though several years his senior. This early friendship lasted through Lindley's life and exercised considerable influence upon his career. After a somewhat troubled youth, owing in large measure to financial difficulties, Lindley left home and went to London in 1819. The narrow limitations of a country life with only slender means chafed him exceedingly, for he was scientific in his tastes, and had not a little ambition. His first piece of scientific work was undertaken during a visit to Hooker in that year, and it was very characteristic of the restless energy and the dogged perseverance which characterised his later career. It was a translation of Richard's *Analyse du Fruit* which was making something of a stir at the time. Lindley spent at a sitting three days and two nights upon his task, and produced a complete English rendering of the book. Upon its completion Hooker gave him an introduction to Sir Joseph Banks, who realising that here was another ardent scientific spirit, made him assistant-librarian to Robert Brown who was then in charge of the treasures in Soho. Before his death in the following year Banks introduced him to Cattley for whom Lindley edited the *Collectanea Botanica*, which was published in 1821. This greatly enhanced the editor's reputation and he was made a member of the Imperial Academy of Naturalists of Bonn.

The Horticultural Society which had been founded nearly twenty years before had, during its somewhat struggling existence, made several attempts to found a garden distinct from the Physic Garden at Chelsea. The Society became possessed this year of thirty-three acres of land at Chiswick, which it devoted to that purpose. Lindley was invited to superintend its construction, and while he was so engaged he, in 1822, became garden assistant-secretary to the Society. This was his first great charge as a horticulturist, and it had for him all the charm of a first undertaking. He never lost touch with the Society during the time when he had risen to

eminence—indeed, he was practically the mainspring of the Horticultural Society while he lived. In 1826 he became Assistant-Secretary and in 1830, on the resignation of Sabine, he became Honorary Secretary jointly with Bentham, later joint author of the *Genera Plantarum.* By their united efforts they set the Society free from a mass of financial difficulty which it had incurred, and brought it into prominence by organising horticultural exhibitions.

It was in these early years that Lindley began to turn his attention to the question of classification. He seems to have been extremely unfavourably impressed by the artificial system, and indeed, in many instances, wrote and spoke in very disparaging terms of the illustrious Swede. At the time the new views had not found very adequate expression in England, where Hudson's *Flora Anglica* was still the standard work. An effort which had not met with very great success, was made in 1821 by J. E. Gray, who lectured on botany at the Borough School of Medicine. He taught the views of De Jussieu in various places in London, and in the year mentioned issued a *Natural Arrangement of British Plants.* It appeared under his father's name, but most of it was due to himself with the assistance of his brothers and of Salisbury, Edward and J. J. Bennett, De Candolle, and Daniel. Though a keen naturalist he abandoned the study of botany owing to the non-success of his candidature for the Fellowship of the Linnean Society in 1822, his rejection being, however, due to something in the nature of private pique, and not in any way a reflection upon his scientific standing. He subsequently devoted himself to zoology, and became Keeper of that department of the British Museum in 1840.

Gray's book did not take any very marked position in literature. At the time the Linnean system had many staunch defenders, including the leading botanists, with the exception of Robert Brown. For the most of the second decade of the century the subject was always prominent in Lindley's thoughts, but his time for the necessary research was limited, and it was not till 1829 that he entered the field as a propagandist. In that year he published a *Synopsis of the British Flora*, which, except for the work of Gray, was the first attempt to arrange British plants on a natural system, and was intended to point the way for the supersession of the books of Hudson, Withering, Curtis, and J. E. Smith.

It may be noted here that the number of species known had been immensely increased owing to explorations in the interval.

Lindley spoke of 92,000 in 1830, while only 20,000 were known to De Jussieu in 1789.

In the next year, 1830, appeared Lindley's first definite classificatory proposals in the form of *An Introduction to the Natural System of Botany*. It was, however, only provisional; but fundamentally it showed some modifications of De Candolle's plan; the apetalous and polypetalous plants were thrown together, the Vascular Cryptogams removed from the Monocotyledons, and the sequence of natural orders changed. It took the following shape:—

CLASS 1. VASCULARES OR FLOWERING PLANTS:—
Sub-class 1. *Exogens or Dicotyledons*
Tribe 1. Angiospermæ
Sec. 1. Polypetalous, apetalous, and achlamydeous plants
Sec. 2. Monopetalous plants
Tribe 2. Gymnospermæ
Sub-class 2. *Endogens or Monocotyledons*
Tribe 1. Petaloidæ
,, 2. Glumaceæ

CLASS 2. CELLULARES OR FLOWERLESS PLANTS:—
Tribe 1. Filicoideæ or fern-like plants
,, 2. Muscoideæ or moss-like plants
,, 3. Aphyllæ or leafless plants

It was evident so far that Lindley had not broken away from the influence of the current thought of the time among the more advanced botanists. He had enunciated no principles on which to work out a scheme. These, however, appeared later, and though they did not find their full pronouncement for several years they can be seen to have influenced him in developing his proposal, as he did from time to time during the next fifteen years.

Lindley states his views on system in the introduction to the *Vegetable Kingdom* in 1845: "Ray added much to the knowledge of his predecessors, and had so clear and philosophical a conception of the true principles of classification as to have left behind him in his *Historia Plantarum* the real foundation of all those modern views, which having been again brought forward at a more favourable time by Jussieu are generally ascribed to that most learned botanist and his successors. . . . The investigation of structure and of vegetable physiology are the foundation of all sound principles of classification. . . . The true principles of classification . . . were in reality expressed by Ray, when he defined a natural system to be that *which neither brings together dissimilar species, nor separates those which are really allied*."

But when we scrutinise these statements we find reasons why it was inevitable that Lindley should fail in basing a successful scheme upon them. Ray did not express in the sentence he quotes any principles at all ; he did no more than set out the object at which he was aiming, and said nothing as to the points which mark similarity or true alliance.

Lindley's own principles proved totally inadequate for his purpose when he came to apply them. His insistence on physiology, where De Candolle had demanded morphology and structure, was undoubtedly retrograde. Physiological or vegetative organs show more variability than any other parts of the plant, and respond more easily to the action of the environment. If we trusted to physiological peculiarities we should be able to form a classification, but it would be into groups related to their habitats, halophytes, xerophytes, mesophytes, and so forth, but they would not give us clear ideas of relationship. Indeed, their resemblances would in large measure be homoplastic. As we shall see, in so far as Lindley used only physiological features in his arrangements he failed. Where, on the other hand, he adhered to morphology he was to a certain extent successful.

Lindley, however, was very definite in his views, and very clear in his expression of them. Many a systematist of the time fell far short of him in this respect ; satisfying themselves with the construction of groups which they held to be natural, and allowing or requiring their students to find out for themselves why such groups must be accepted. Lindley says of botanical characters : "The only intelligible principle by which to estimate their respective value is according to their known physiological importance ; regarding those organs of the highest rank which are most essential to the life of the plant itself ; placing next in order those with which the plant cannot dispense if its race is to be preserved ; assigning a still lower station to such organs as may be absent without considerable disturbance of the ordinary functions of life ; and fixing at the bottom of the scale those parts, or modifications of parts, which may be regarded as accessory, or quite unconnected with obviously important functions." He then goes on to lay down the principle that first in order must come nutrition, and second to it propagation—a sequence that has nothing to commend it. A little later he says, "Physiological characters are of greater importance in regulating the natural classification of plants than structural," and illustrates this statement by putting down in order the points on which he

laid stress, these being: (1) Modifications of organs of either vegetation or reproduction; (2) internal structure of axis and foliage; (3) internal structure of the seed; (4) structure of organs of fructification, *e.g.* anthers, placentæ, and ovules; (5) the floral envelopes; (6) the symmetry of the flower.

His application of these points is summed up in the sentence: "The great classes of plants are principally distinguished by their organs of growth; in the numerous minor groups such peculiarities are comparatively disregarded, their chief distinctions being derived from their parts of reproduction."

It is easy to see that a classification based upon such a method would be full of inconsistencies, and would certainly not secure what Ray had pointed out to be the solution of the problem. It would be, indeed, fundamentally different from that which has ultimately come to receive acceptance, so far as its broad outlines are concerned.

Nor was Lindley consistent in the planning of his scheme. In another place he says: "That which really determines affinity is correspondence in structure. It may be said that those plants are most nearly related which correspond in the greatest number of points, and those the most distantly in which we find the fewest points of correspondence; and this must be true when we remember that if every point in the structure of any two plants is found to be alike, then those two must be identical." Here he is clearly voicing the views of De Candolle, and putting morphology in its true position.

While we can only regret that Lindley showed much confusion in constructing the framework of a natural system, and failed to find sound principles on which to found it, we must give him full credit for realising that to convince the botanical world of the value of any particular arrangement the latter must be shown to rest on definite principles and to be no haphazard grouping together of organisms only superficially resembling each other. He was certainly the first botanist in England to attempt to secure an assent to his proposal based upon an understanding of them, and perhaps the first to advance any arguments of value as to the nature of affinity. It is not surprising that his attempts were but partially successful. It is difficult to-day to go back in thought to a time when no account was taken of descent in determining affinity, when the idea of the fixity of species was dominant, and when the day of the evolutionary hypothesis had not dawned. Such was, however, the state of knowledge when Lindley and his

fellow-workers were groping in the dark to find the real meaning of affinity. How they were perplexed, and how they deplored their perplexity may be seen from remarks which occur here and there in their writings: "In natural science there is no beginning and no end." "It is impossible, from the nature of things, that any arrangement should exist which shall represent the natural relations of plants in a consecutive series."

How greatly Lindley felt his system to be unsatisfactory is shown by the continual alterations which he made to it, changing it from time to time, without however altering its fundamental basis.

The first amendment appeared in 1833, and seems to have been brought about in consequence of the work of Agardh and of Bartling on the Continent. It had always been felt by him that De Jussieu's system was defective in that it did not supply any intermediate groups between his natural orders and his classes. Nor had any one succeeded in doing so. De Candolle in his earlier work introduced the cohort, but in later editions of his book the idea was abandoned. Brown, as we have seen, and as Lindley pointed out with some emphasis, had called attention to the necessity of arranging such groups of orders. The small groups were more or less satisfactory; Tournefort had defined genera, Linnæus had given precision to species; De Jussieu and De Candolle had formed larger divisions continuing and extending the work of Ray. Bartling in 1830 had put forward elaborate proposals to fill the gap, and found groups of orders subordinate to the higher divisions. Lindley drew attention to the grave difficulties attending strict and exclusive delimitation of natural orders, and showed how they merged almost one into another, so that it was difficult to have complete agreement as to which order some particular genus should be placed in, and suggested that really no fixed limits exist, and that what were called natural orders were to be considered "as nothing more than the expression of particular tendencies on the part of the plants they comprehend, to assume a particular mode of development." He accordingly arranged into groups such orders as seemed to merge together, calling them *Nixus* (tendencies). This was to a certain, indeed a considerable, extent an improvement on his scheme of 1830, but the delimitation of the new groups left much to be desired. The new proposals were the first exposition of the kind of system to be derived from the use of a physiological basis; in the preface to it "he maintained that no sections are capable of being positively defined, except such as depend upon physiological peculi-

arities; and that all other collections of species, by whatever name they are known, whose distinguishing marks are dependent upon structure alone, merely exhibit tendencies to resemblance in certain points, for which tendencies definitions are impracticable."

The outlines of the scheme are as follows :—

Sexuales
- Vasculares
  - Exogenæ
    - Angiospermæ
      - Polypetalæ
        - Cohort 1. Albuminosæ: Embryo much smaller than the albumen
        - „ 2. Gynobasicæ: Carpels arranged round an elevated axis
        - „ 3. Epigynæ: Ovary inferior, generally with an epigynous disc
        - „ 4. Parietales: Placentæ parietal
        - „ 5. Calycosæ: Calyx incompletely whorled, two sepals exterior
        - „ 6. Syncarpæ: Carpels consolidated, with none of the characters of the other cohorts
        - „ 7. Apocarpæ: Carpels distinct, with none of the preceding characters
      - Incompletæ
        - Cohort 1. Tubiferæ: Calyx tubular, often petaloid
        - „ 2. Curvembryæ: Embryo curved round albumen; calyx rarely tubular
        - „ 3. Rectembryæ: Calyx imperfect, embryo straight
        - „ 4. Achlamydeæ: Calyx and Corolla wanting
        - „ 5. Columniferæ: Stamens monadelphous
      - Monopetalæ
        - Cohort 1. Polycarpæ: Hypogynous, rarely epigynous, ovary polycarpous
        - „ 2. Epigynæ: Epigynous, ovary 2-∞ celled
        - „ 3. Dicarpæ: Hypogynous, regular, ovary dicarpous
        - „ 4. Personatæ: Hypogynous, irregular, ovary dicarpous
        - „ 5. Aggregatæ: Ovary one-celled
    - Gymnospermæ
      - Cycadeæ, Coniferæ, Taxineæ, Equisetaceæ
  - Endogenæ
    - Cohort 1. Epigynæ: stamens distinct, ovary inferior
    - „ 2. Gynandræ: anthers united, ovary inferior
    - „ 3. Hypogynæ: flowers 3-merous, coloured, ovary superior
    - „ 4. Imperfectæ: flowers herbaceous or imperfect or none; or finally of two parts and coloured, with a superior ovary
    - „ 5. Glumaceæ: scale-like bracts in place of a perianth.
- Evasculares
  - Rhizantheæ

Esexuales. (This includes the Ferns, Club mosses, Mosses, Algæ, and Fungi.)

The defects of the scheme are very prominent. Ray's fundamental distinction entirely disappears; the prominence given to axial structure leads to incomplete recognition of Brown's work on the Gymnosperms, which are made only a group of Exogens,

and placed above the Endogens (Monocotyledons), while the Equisetaceæ are included with them; the parasitic Rafflesiaceæ are grouped with the Balanophoreæ and other parasites solely on the ground of their parasitism, and the grave structural differences in the ill-assorted group are ignored, while the whole collection is made co-ordinate with the Exogens and Endogens.

The nomenclature of the Nixus or Cohorts is unsatisfactory, the term Epigynæ, for example, occurring in several places, with considerable risk of confusion. At the same time it must be admitted that several of the Cohorts were constructed with skill, and have remained with little alteration to the present day.

While these intricate problems occupied his thoughts, Lindley's work was by no means confined to the study. Essentially a public man he was prominent in other circles than those of science. He was elected to the Chair of Botany in the newly established University of London in 1829, and was a very successful teacher there. In the year 1835 he was made *præfectus horti* at Chelsea, and Professor of Botany to the Apothecaries' Company, a post he filled with great distinction for seventeen years. As a teacher he was conspicuous for exactness and lucidity, with a special gift for appropriateness of illustration. He insisted on teaching not from the theoretical side only, but supplied his students abundantly with specimens which were selected from the particular natural orders with which he was for the moment concerned. His lectures, too, were largely catechetical.

Of his work at Chelsea we shall speak later in connection with the story of the progress of the garden.

These labours gradually secured for Lindley the reputation of being one of the leading botanists of Europe, and he was the recipient of honours both at home and abroad. He became a Fellow of the Linnean Society in 1820, and of the Royal Society in 1828, while the University of Munich conferred upon him the honorary degree of Doctor of Philosophy in 1832.

Other work done by Lindley in his early years in London included the assistance he gave to Loudon in bringing out his *Encyclopædia of Gardening* in 1822. Most of the descriptions of the plants in this volume were from his pen, and were only instances of the attachment he always showed to horticulture.

During the early thirties his manifold occupations, engrossing as they must have been, did not take his attention off his intense desire to frame a satisfactory natural system, a hope which, elusive as it proved, was never far from his heart.

In 1836 he brought out a second edition of his *Natural System of Botany*, in which he introduced further changes. They were, however, in the main confined to questions of nomenclature, which call for no comment.

Two years later, however, in an article on Exogens, in the *Penny Cyclopædia*, he put forth some very revolutionary proposals for the treatment of his group, Angiospermæ, of 1830. Instead of taking as a guide the morphology of the flower, as all his predecessors since De Jussieu had done, he framed his subdivisions on the structure of the seed, with special reference to the amount and distribution, or as he probably intended, the presence or absence of albumen. As a second and subordinate mark of distinction he used the presence of both stamens and carpels in the flower. His proposals were the following :—

Exogens	
Tribe 1. Angiospermæ	
Albumen abundant. Embryo minute	Albuminosæ
Albumen absent or scanty	
Sexes in the same flower	
Ovary inferior	Epigynosæ
Ovary superior	
Flowers if monopetalous not with a dicarpous ovary	Polycarposæ
Flower monopetalous, ovary dicarpous	Dicarposæ
Sexes in different flowers	Diclinosæ

The rest of the system remained unaltered, so that the new proposals were to substitute five fresh divisions for the old monopetalous, apetalous, and polypetalous divisions.

Lindley held that "each of these groups would form a series by itself, the sequence of which ought to be natural and to exhibit various lateral analogies with other groups." But he seems to have been alone in the opinion ; no other botanist has accepted the division.

Probably its unsatisfactory character soon became evident to himself, for we find him in 1839 coming forward with another plan, an "extension of the primary classes of plants," which he published in the *Botanical Register*. It was the following :—

State I. Sexual or Flowering Plants

Division 1. Exogens	Cyclogens	Class 1. Exogens
		,, 2. Gymnogens
		,, 3. Homogens
Division 2. Endogens	Spermogens	,, 4. Dictyogens
		,, 5. Endogens
		,, 6. Sporogens (Rhizanths)

STATE II. ESEXUAL OF FLOWERLESS PLANTS

Division 3. *Acrogens* { Class 7. Cormogens
,, 8. Thallogens }

It is clear that such a rapid output of systems, whose very bases were continually shifting, could have been of no permanent value. Scrutinising them one by one it becomes evident that Lindley found the principles on which he apparently relied failed him entirely. He could not make the proposals consistent with one another, nor could he apply his principles to a single scheme in their entirety. He was wandering further than ever from the light of Ray and De Jussieu, still he could not rest content to leave the subject in the hands of others but was in a continual state of unrest as he contemplated the comparative chaos in which it lay.

Lindley's industry was prodigious. Not content with his own literary work and his many official duties, he found time to collaborate with several other authors in different undertakings. A large selection from Bauer's beautiful drawings of the Orchidaceæ were lithographed under his auspices and were published by him during the years 1830 and 1838, under the title *Illustrations of Orchidaceous Plants*. In 1838 a further collection appeared—*Sertum Orchidaceum*—the illustrations to which were drawn by Miss Drake. The letterpress of all these was Lindley's own. He completed the publication of Sibthorp's *Flora Græca* between 1833 and 1840, three volumes being brought out under his editorship. During 1831-37 he found time to collaborate with Hutton in the preparation of what was for long in England the standard work on Palæophytology, the *Fossil Flora of Great Britain*, a publication to which attention must be called a little later. He wrote all the botanical articles down to R in the *Penny Cyclopædia*, and brought out the *Flora Medica* in 1838. Always a practical horticulturist as well as a botanist he wrote and published in 1840 a great treatise on the *Theory of Horticulture*, long the standard work upon the subject. It was reproduced in America and subsequently translated into almost every European language. Another volume of a kindred nature was the *Flower Garden*, which he brought out jointly with Sir Joseph Paxton in 1850. He conducted the publication of the *Botanical Register* except during the first few years ; he started in 1841 the well-known *Gardener's Chronicle*, and filled its editorial chair for twenty-five years. The pages of the *Linnean Journal* and *Transactions* also bear testimony to the

activity of his pen. In 1841 he took up the office of Vice-Secretary of the Horticultural Society on the resignation of Bentham, and was made Secretary in 1858, holding that office till 1862.

In the midst of all this labour Lindley found time to make one further contribution to classification. He remodelled his plans of 1839 and after a great deal of elaboration in detail, he put them forward in what we must consider his *magnum opus*, *The Vegetable Kingdom*, which appeared in 1845, and consisted of nearly a thousand pages. It was chiefly founded on material which he had collected with a view to the preparation of a *Genera Plantarum*, which, however, he was never able to carry out. An outline of these proposals is the following :—

Asexual or Flowerless Plants	
Stems and leaves undistinguishable	Class 1. Thallogens
Stems and leaves distinguishable	,, 2. Acrogens
Sexual or Flowering Plants	
Fructification springing from a thallus	Class 3. Rhizogens
Fructification springing from a stem	
Wood of stem youngest in the centre; cotyledon single	
Leaves parallel-veined, permanent; wood of the stem always confused	,, 4. Endogens
Leaves net-veined, deciduous; wood of the stem when perennial arranged in a circle with a central pith	,, 5. Dictyogens
Wood of stem youngest at the circumference, always concentric; cotyledons two or more	
Seeds quite naked	,, 6. Gymnogens
Seeds enclosed in seed-vessels	,, 7. Exogens

These larger groups comprised varying numbers of natural orders which Lindley divided into several groups according to his views on their relationships. He abandoned the term Nixus for these, substituting "Alliances," and taught that there is no sharp line of demarcation of these, but that they pass insensibly into each other, or have "a strong lateral relation." His treatment of the constituent natural orders is exhaustive, many of them being practically monographs. He dealt not only with their botanical relationships, but their distribution, their medical virtues and their economic uses. He also gave with each a list of the genera which he held to belong to it.

We cannot but admire the completeness of his treatment of these smaller groups, the work, indeed, resembles an encyclopædia rather than a botanical treatise.

But when we compare this, his last word on system, with the

sketches he had made in earlier years there comes to us no feeling of satisfaction. His classes show no advance more likely to be permanent than his proposals of 1839. He showed in it great brilliance of detail, but no power of generalisation, and his scheme exhibits marks of incoherence. He still adhered to the utterly bad group, the Rhizogens or Rhizantheæ, based upon no relationship but that of a common parasitism, though so acute an observer as Robert Brown had shown such a division to be unscientific. In his remarks on the constitution of the group he supports it strangely in the following words: "Most of the species brought together to constitute the class of Rhizogens seem to have little relation to other parts of the system. It is true that the genera differ much from each other in the details of their fructification; though not more than the genera of some other classes: but the character of the order does not depend on the fructification. It depends upon the great peculiarity in the manner of growth, already pointed out; and the fructification is connected with questions of a subordinate degree. All the classes of plants depend equally upon such considerations; and therefore Rhizogens are logically a class." Here one hardly knows whether to be surprised more at his shortsightedness in basing a great class upon "peculiarity in the manner of growth," or the weakness of his logic in defending his position. He was sadly misled by his avowed belief in physiological peculiarity as a basis of relationship.

The position he assigned to his Gymnogens is another very unsatisfactory feature of the scheme. Many years before, in 1825, Robert Brown had established the group, and in 1834 and again in 1843 had in addition called attention to the peculiarities connected with its embryogeny, showing clearly that the relationship between it and the Dicotyledons or Exogens was by no means close. Yet Lindley gives as the chief mark of the group: "Gymnogens are known from most other vasculares by the vessels of their wood having large apparent perforations or disks." He does not call attention to Brown's most momentous discoveries, strangely enough ignoring the question of the formation of the albumen, a matter which he deemed so important in his proposals of 1838.

The Dictyogens consisted of only five small natural orders, all poor in species, presenting no particular alliance and having no very marked characters. No other writer has admitted the propriety of separating them from the rest of the Monocotyledons (Endogens).

The Exogens were subdivided into four groups or sub-classes on the following grounds:—

Flowers absolutely unisexual	Sub-class	1. Diclinous
Flowers hermaphrodite		
Stamens not adhering to either calyx or corolla	,,	2. Hypogynous
Stamens adhering to either calyx or corolla	,,	3. Perigynous
Stamens, calyx, and corolla all adhering to the side of the ovary	,,	4. Epigynous

As the author points out, this is essentially the old plan of De Jussieu. Consequently, it appears that Lindley's emendations of De Candolle's proposals are either retrograde or so controversial as to be impossible of acceptance. It is very strange that with his expressed regard, or even veneration, for Ray, he departed so completely from the lines the latter laid down, and abandoned the utilisation of the great division with which Ray's name will always be associated—the Monocotyledons and the Dicotyledons.

In these groupings Lindley adhered more or less closely to his principle that classification must be based in the first instance on physiology and to a less degree on structure. We have already noticed what an unsafe guide the former of these must be; he was almost as unfortunate in the stress he lay on structure and the interpretation he gave it. Internal structure was very imperfectly known and Lindley seems to have been somewhat behind the times in his acquaintance with it. He laid down as a fundamental distinction between Exogens and Endogens what he called exogenous and endogenous growth of the stem. Any one reading his description of the latter as given in the *Vegetable Kingdom*, must realise that he had no accurate conception of the mode of growth of such stems. The same in a measure may be said of his ideas of the growth of an Exogen. Cambium was to him a viscid substance secreted between the liber and the wood. The connection between leaf and stem was stated thus: "The ligneous cords in the leaves are prolonged into the stem, passing down among the cambium, and adhering in part to the wood, and in part to the liber of the previous year, the former again having vessels intermingled with them, the latter having none." When speaking of anatomical differences between the two groups, he said: "In many of the larger kinds of Endogens the stem increases principally by the development of a single terminal bud, a circumstance unknown in Exogens properly so-called." He insisted on the validity of his views on the differences in the growth of the axis in the two great classes, though von Mohl had shown many years before that

the conception was not well founded. At the time at which he was writing it is abundantly clear that neither anatomy nor physiology was sufficiently understood to supply the details of the basis he was insisting on, even had such basis been scientifically sound.

But we must admit a few serious defects even if his basis of classification could be accepted, though perhaps they did not become apparent until long after Lindley's death. In his diagnosis of an order he selected the technical characters which he ascribed to it from some one or two genera which he held to be typical, and in some cases his selections were unfortunate, proving inapplicable to the great bulk of the order, or in some instances founded wholly on error. In many cases they require considerable extension owing to a failure on his part to estimate completely their relative importance.

Much as we can appreciate his plan of grouping the orders together on the grounds of their affinity, his mode of carrying it out was in many respects faulty. Like so many men of his time he held that an absolute scale of the relative value of characters founded on their degree of constancy could be drawn up, and on such scale he based his conception of affinity. But later work has shown the inadequacy of any such scale, the impossibility, indeed, of constructing one. As Lindley applied it, it often led him in the wrong direction, and hence we find many instances of orders separated from their natural allies and classed with others which they resemble much less closely. We have, indeed, the clue to his mistakes in the fact so often commented on before, that in his day the fact that affinity is an expression of phylogeny had not been realised.

But though not admitting that Lindley achieved any very great measure of success in framing his general scheme, we may well admit that he made his mark among taxonomists. His work on the natural orders may well atone for what was only speculative as to the limits of the larger groups. His descriptions of the orders were complete, even exhaustive, and his discussions of their relationships and his grouping of them into alliances were distinctly valuable. Sachs says that he possessed a correctness of feeling, which was formed and continually being perfected by constant consideration of the forms of plants, and that so endowed, he obtained a real success in the determination of affinities.

In his larger speculations Lindley presents to us something of a puzzle ; he laid down decidedly and with emphasis, what he con-

sidered the true principles of classification—a course which he was almost the first to take. On the other hand, he did not finally base his classification in any great detail upon those principles. His repeated sketches of systems show him toying with one and another point, perhaps of physiology, perhaps of anatomy, but in its final form his scheme shows that he held them very lightly and abandoned one after another in turn. A survey of his system shows, indeed, that it is more a morphologically natural system than anything, while it recognises groups that are essentially natural and not based on his principles. The Cruciferæ, the Umbelliferæ, and several other groups will serve as instances of this curious departure from both anatomy and physiology.

The production of the *Vegetable Kingdom* in 1845 was Lindley's last word on classification. It saw two more editions, the last appearing in 1853, but there was practically no change in them, though more and more detail was incorporated into each.

The other literary work to which attention has been called, occupied most of his leisure. In his later years he continued much of it, though he gradually became more and more absorbed in administrative duties. He published a second edition of the *Theory and Practice of Horticulture* in 1855; in the years 1852-55 he turned his attention again to the Orchidaceæ, a group which always possessed a fascination for him, and he commenced a further work on the subject, to which he gave the name *Folia Orchidacea*. This was, however, never completed. His work on the Orchidaceæ was of a very high order, particularly the delimitation of its genera and species. He estimated the number of the former at 469 and of the latter at about 3000, much smaller figures than are acknowledged to-day. His descriptions were clear and graphic, and his groups so well chosen that they were accepted for long after his lifetime, indeed, many of them survive to-day with but little alteration.

After 1850, as we have seen, administrative work claimed much of his time and thought. In the great exhibition of 1851 he was one of the jurors who were asked to report on substances used as food, when his arduous duties caused him a severe illness. In the course of the next ten years he was occupied in the pursuits which have been described; with the oncoming of the exhibition of 1862 he was again subjected to strenuous toil, for he undertook the charge of the Colonial Department, much against the advice of his friends. It was a hard struggle, maintained with the utmost tenacity. When the strain was removed, the reaction was very

serious. His mental and physical powers gave way, and he was obliged to retire from active work. He died suddenly of apoplexy in 1865.

Lindley's taxonomic work was, perhaps, the most characteristic of him, and certainly not the least valuable. Though in the light of more modern reasoning it is open to criticism, it was the expression of the unrest of the time, and the effort to find a solid basis for classification, an effort which seems to be a continuous groping after light. It must be remembered in judging it, that many countries remained unexplored and the floras consequently unknown, so that no completely inclusive grouping could be made. Large as was the number of species that had been collected, knowledge was not sufficiently complete for a satisfactory classification that should be exhaustive.

Of Lindley's work in yet another field, something must be said. In conjunction with Hutton he published in the early thirties of the last century a classic work on the *Fossil flora of Great Britain*, which gave in three volumes the figures and description of all the fossil plants then known. Reference will be made to this in a subsequent section.

CHAPTER XXXVII

BOTANIC GARDENS IN LONDON

Kew Gardens, from Banks to Hooker

The death of Banks in 1820 was a great blow to the development of Kew. He had initiated a policy and had seen its leading movements inaugurated, but he had been feebly supported and had not gathered around him any adequate staff. The younger Aiton was nominally in direction of affairs, and on him after Banks had gone the chief responsibility fell. Banks's last years had been marked by considerable discouragement, for his plans depended largely on the co-operation of the King, and for many years before 1820 George III. had been mentally afflicted. The Prince Regent cared little for Kew and its concerns, and to a large extent, therefore, Banks had been greatly hampered.

Still, there was much more enterprise shown than before Banks came upon the scene. He had started several enterprises which had become in a sense a tradition, and under Aiton's management they were continued. The affairs of the gardens were conducted on the old lines, and collectors were from time to time sent out to different parts of the world.

But the loss of a skilled director like Banks could not fail to be severely felt. Though his machinery remained, the enthusiasm that had been the driving power had almost entirely vanished, and the fortunes of Kew seemed at a very low ebb. The only man who seemed at all deeply concerned in the maintenance of the institution was the Curator, John Smith, but for whose fostering care even the living plants might have perished.

During these dark days a few circumstances call for notice. In 1818 the first Himalayan rhododendrons were introduced, seeds being sent by Wallich from Nepaul. A collection of living orchids was brought over from Trinidad in 1833 by George Aldridge, and Barclay in 1841 introduced many rare specimens from South America and the islands of the Pacific Ocean.

In 1823 Hunter House, a mansion standing close to the gardens, became the property of the nation. Banks had entertained the idea of converting it into a herbarium and library, and certain

steps had been taken in that direction, but from various circumstances the design was abandoned, to be taken up again, however, under Sir W. J. Hooker in 1852.

A description of Kew in 1829 is given by Professor Schultes in the work already referred to. Speaking of his visit to it he said: "We did not see Mr. Townsend Aiton, as he had been called away to Windsor; but in this well-known garden, whose Catalogue has given it so much celebrity, we did not find the pleasure that we had anticipated. We were disappointed particularly in the plants which grow in the open air, which are not so accurately named as those in the Göttingen Botanic Garden, superintended by Schrader; sometimes the same species is marked with two different names. The garden at Kew consists of a fine park, and a large botanical garden of about twenty acres. . . . The Botanic Garden at Kew is surrounded by high walls, and intersected into long squares. With regard either to its plan, or its nine or ten stoves, it will not bear a comparison with those of Malmaison, or the Grand Duke of Weimar, or Prince Esterhazy at Eisenstadt, or even with the botanical division of the Imperial Garden at Schönbrun."

Neither George IV. nor William IV. took much interest in Kew, and their reigns were almost barren of results to botany there. In the time of William IV. the great conservatory which now stands near the main gate of the gardens was removed there from Buckingham Palace, being at first used as a palm house.

But after the death of the King the gradually growing discontent of the English scientific world with the stagnation of Kew began to make itself felt, and as a result the Government in 1838 appointed a committee to inquire into the state of the gardens. It consisted of Dr. Lindley and two specialists in gardening, one of whom was Sir Joseph Paxton. Their report showed that the garden occupied "fifteen acres, of which part is Arboretum, and the remainder filled by stoves and greenhouses, borders of herbaceous plants, spaces left for the arrangement of greenhouses, plants in the open air in summer, yards, offices, etc. The Arboretum contains many very fine specimens of hardy trees and shrubs, but the collection is not very extensive, and the plants are too much crowded. The collection of herbaceous plants appears to be very inconsiderable. . . . No systematical arrangement is observable with the exception of Grasses."

John Smith, at that time foreman and subsequently the first Curator of Kew after it became a national establishment, accounts

in part for the drastic character of the report by the fact that the preceding winter had been one of the severest on record. "The herbaceous collection, if it had been examined in summer and time taken, would have been found to contain about 2500 species of the perennial plants, arranged according to the Linnean system."

The report said that the ten stoves and greenhouses were excessively crowded, but admitted that the plants, especially those from New Holland, were well attended to. From other sources we know that the collections of Cape and New Holland plants were incomparable.

Smith showed, further, that Kew had supplied many of the Colonies with rare plants. Mauritius, New South Wales, St. Vincent, Jamaica, and Trinidad received European plants suitable to their climate, while a large collection of succulent plants was sent to Calcutta. The collections of European botanic gardens also were enlarged by gifts from Kew. In 1797, 230 species of plants were sent to the Grand Duchess of Russia.

After the peace of 1814, Professors Wendland of Hanover, Fischer of St. Petersburg, Martins of Munich, Link and Otto of Berlin, Reinhardt of Leyden, and Sagasca of Madrid visited Kew from time to time, and selected many specimens for their gardens.

The circumstances of the appointment of the commission referred to are especially interesting. As we have seen, the gardens were the private property of the Sovereign, and on the accession of Queen Victoria there was considerable discussion as to the desirability of their remaining so. Some of the high officials of the state objected on the ground of the necessity of considerable extension from time to time if their utility was to be maintained, and agreed in favour of their being made a national institution. This extension did not seem possible, moreover, if the royal palace was to be retained. Objections were raised, on the other hand, to the probable extensions on the ground of the large expenditure that would be involved. There was consequently a party in favour of abandoning them entirely as a botanical institution. In 1839 Lord Surrey, the Lord Steward, proposed to convert the greenhouses and pits into vineries, but public opinion compelled him to desist. He actually offered the Kew plants at first to the Royal Horticultural Society for their garden at Chiswick, and afterwards to the Royal Botanical Society for their new establishment at Regent's Park, but both societies refused to accept them. When these proposals became known there was some excitement, and the Earl of Aberdeen obtained

a guarantee in parliament that the plants should not be moved. Dr. Lindley's commission was appointed not only to report on the state of the gardens, but to consider the question of their retention or nationalisation, and they strongly advised the latter step. The Duke of Bedford, grasping the whole position perhaps more clearly than any other statesman, interested himself with much earnestness in the controversy, and endeavoured to get the nationalisation adopted and the gardens put under the charge of Sir William J. Hooker, whose work at Glasgow had been so conspicuously successful. He died before the matter was settled, but his sons, the new duke and Lord John Russell, took up the negotiations. Success attended their efforts; the Queen gave up the gardens, and they were put under the charge of the Commissioners of Woods and Forests, with a sum of £800 a year towards the expense of their maintenance. The question of expense, indeed, bulked largely in the eyes of the opponents of the scheme. Ultimately the progressive party were completely successful; the Treasury appointed Hooker Director of the gardens, giving him a free hand and a promise of a favourable consideration of such improvements as he felt justified in projecting. His appointment was made possible at this juncture by the retirement of Aiton, which took place towards the end of 1840. No conditions were imposed at the time as to his management of affairs, but in 1844 he was instructed to make an annual report on the progress of the gardens to be presented to parliament. He was asked at the same time to prepare a guide-book, which could be sold to visitors at the entrance to the grounds.

The Royal Horticultural Society's Garden at Chiswick

In the last chapter allusion was made to the formation of the Royal Horticultural Society at the beginning of the nineteenth century. It seems to have originated through a letter addressed to William Forsyth, the successor of Philip Miller at Chelsea, and later superintendent of the Royal Gardens at St. James's and Kensington. John Wedgewood, son of the inventor of the Wedgewood pottery, and Thomas Andrew Knight, the celebrated vegetable physiologist, the writers of this letter, must therefore be regarded as the founders of the society. It was organised at the house of Mr. Hatchard, the Piccadilly publisher, and among the original members besides those already mentioned were Banks and Aiton. A Royal Charter was granted to the society

in 1809 by George III., and in 1810 it began to issue its *Transactions*. In 1810 Joseph Sabine became secretary, and to him largely its success was due. He reorganised it soon after taking office, and was awarded its gold medal in 1816. He took a large share in the enterprise which had already been one of the projects of its founders, viz. the establishment of a botanic garden in connection with its work. The design, however, could not be carried out in the early days of the Society, and two small experimental plots were started in 1818 with the view of practically testing therein the value of flowers, fruits, shrubs, and trees, that promised to be desirable horticulturally, or to be economically important to British commerce. Four years later the larger scheme was carried to success, and a garden at Chiswick was obtained on a lease from the Duke of Devonshire, an enthusiastic supporter of the society, who subsequently became its president. Sabine retired in 1830.

Professor Schultes, who visited the garden in 1829, wrote of it: "The garden of the Horticultural Society at Turnham Green is of far greater importance to the art of gardening, which is indeed the proper design of the study of botany. This establishment is likely to prove of incalculable advantage to Britain and to all Europe; every branch of Horticulture except the ornamental being here pursued to the greatest extent and according to the purest scientific principles; such as the cultivation of fruits and vegetables, both forced and in the open air; and of flowers, whether abroad or under glass. No less than 33 acres of land are destined to the accomplishment of the necessary experiments, surrounded by a lofty wall, and again walled off into partitions. . . . At present there are five stoves, two of them built after the newest plan, with convex windows, which are found to be highly advantageous. A very large house is to be erected next year, and heated by steam. . . . The Horticultural stoves contain many valuable plants from China and Sierra Leone; brought by Mr. Don's brother, who had resided there for some time. So fine a collection of Roses exists nowhere else; the celebrated Mr. Sabine, who is Secretary to the Society, having been engaged in studying this tribe for almost 30 years. They are arranged in large squares; one might almost say, in small groves of roses, native and foreign, single and double. On comparing this garden with those of the ancient Universities of Cambridge and Oxford, one cannot for a moment hesitate in declaring the superior influence that this must have in benefiting the country: although it has only been

formed within these few years, by the joint exertions of a few private individuals."

In 1818 the Society adopted the Kew plan of sending out collectors to foreign countries in search of horticultural rarities, a plan which had been crowned with signal success. One of the earliest of these botanical explorers was John Reeves, who brought back from China the elegant *Wistaria sinensis*. Another was George Don, the eldest son of the Scottish botanist, to whom allusion has already been made. He was at one time employed in the Chelsea Physic Garden, and in 1821 he went to Brazil, the West Indies, and Sierra Leone as collector for the Royal Horticultural Society. He sailed in the *Iphigenia*, under Captain Sabine. His chief work was *A General System of Gardening and Botany*, founded on Miller's *Gardeners' Dictionary*, 1832-38. Besides furnishing the Linnean arrangement to Loudon's *Hortus Britannicus*, he published in the *Edinburgh Philosophical Journal* for 1824 an "Account of several new species from Sierra Leone"; in the Wernerian Society's *Memoirs*, 1826-31, "A Monograph of the Genus *Allium*," and in the Linnean Society's *Transactions* for 1826, "A review of the Genus *Combretum*."

John Forbes was sent by the society to tropical East Africa in 1822. He sent home a considerable number of specimens from Madeira, Rio, the Cape, and Madagascar, and projected a great exploration in the district of the Zambesi, but the hardships of the interior were too great for him, and he died on the way in 1823.

One of the Society's most valued collectors was David Douglas, sent out to North America in 1823. Born at Scone in 1798, he attracted the attention of Hooker while at the botanical garden at Glasgow, and accompanied him on a Highland tour. Reaching America in 1823 he sent home to Chiswick in the same year a very large collection of fruit trees for trial. His exploration of Oregon and the territory of British Columbia, undertaken in the following year, was even more successful, resulting in the introduction of a large number of conifers, shrubs, and flowers. We owe to him *Pinus lambertiana*, *P. insignis*, *P. ponderosa*, *P. contorta*, and *P. monticola*; *Picea bracteata*, *P. nobilis*, *P. amabilis*, and *P. grandis*; also *Abies mensiesii*, and *A. douglasii*, the famous Douglas spruce. A great variety of the flowers of the garden were sent over by him, including, amongst others, species of *Godetia*, *Gaillardia*, *Penstemon*, and *Eschscholtzia*. In 1827 he crossed the Rocky Mountains and reached Hudson's Bay, where he met Sir John Franklin, the Artic explorer, and they returned to England

together. Douglas was made a Fellow of the Linnean, Geological, and Zoological Societies, to whose *Transactions*, as well as those of the Royal Geographical Society, he contributed occasional papers. In January 1828, Lindley dedicated to him the genus *Douglasia* of the natural order Primulaceæ. He sailed on his last journey in the autumn of 1829, and passed the greater part of the next three years in California. From 1832 to 1834 he was on the Fraser River. Whilst on a visit to the Sandwich Islands in the summer of 1834 he fell into a pitfall, and was gored to death by a wild bull. His dried plants were divided between the herbaria of Kew, Cambridge, and the Linnean Society.

At home the Society gave its attention to the progress of horticulture, making extensive collections of plants in its gardens with a view to the elimination of poor varieties, and the improvement of the remainder. In 1823 as many as 1200 varieties of rose plants were gathered together at the garden at Chiswick, and to this collection in conjunction with the society's importations from China we owe the modern rosarium. Experiments were also made continuously as to the best methods of cultivation.

Chelsea Physic Garden: J. L. Wheeler

The resignation of Thomas Wheeler, botanical demonstrator of the garden of the Apothecaries' Company at Chelsea, was not without its influence upon the revival of the natural system in England. The garden had since the time of Philip Miller been a stronghold of the Linnean principles, which had been taught and illustrated there by a succession of demonstrators and gardeners, who had adhered to them with the utmost tenacity. But Wheeler was the last of the Linnean demonstrators, and with his departure changes became imminent. On his resignation the Apothecaries' Company submitted the duties of the office to a revision, and established new conditions for the tenure of the post. It was determined that the new demonstrator should expend a part of the time taken up in teaching, by expounding and explaining the rival systems of Linnæus and De Jussieu, a departure which had momentous consequences, for it led with no very long delay to the disappearance of the former from the classroom. The new conditions called for lectures on the principles of vegetable life and the structure and physiology of plants, in addition to their medicinal properties—in fact, they inaugurated a fairly complete course of botanical study. The hours were not long: the demon-

strations were appointed to be held at 9 a.m., on the last Wednesday of each summer month. For these hours the programme may seem somewhat ambitious, but the state of knowledge of the time did not make many demands upon either teacher or student from the standpoint of either structure or physiology. At the same time the title of professor was substituted for that of demonstrator, and the salary of the office was fixed at £50 per annum. The duties of the superintendence of the apothecaries' apprentices, the direction of the herborising excursions, and other occupations of the demonstrator were continued.

So reconstructed, the post was filled by the appointment of Mr. James Lowe Wheeler, the third son of his predecessor, who occupied the chair for fourteen years. Several quiet years of routine followed till further reforms were made in 1829. For the first time then the gardens were thrown open to all recognised medical students, subject only to their obtaining a recommendation from their teachers, a concession that met with so great an immediate success that a further re-organisation took place in the next year. Greater facilities for study and for teaching were given; the gardens were thrown open every Wednesday during May, June, July, August, and September from 9 till 12 in the morning on the same conditions. A weekly lecture, followed by a demonstration, was given by the professor in place of the old monthly lecture, and an examination for two medals was established to complete the term's work. This larger programme was carried out, and the professor's stipend was raised to £80 per annum. In 1830 prizes were awarded for proficiency in botany, Mr. Wheeler being the adjudicator. He conducted the examinations for some four or five years. During his period of office he prepared and published a catalogue of the medicinal plants, which comprised all those which were admitted into the Pharmacopœias of London, Edinburgh, and Dublin. This catalogue is a little remarkable in showing the spreading of the new ideas at Chelsea. It was arranged on the Linnean system, but an appendix was given which took the form of a synopsis of the plants on De Jussieu's lines.

Henry C. Andrews, a friend of Wheeler's, a resident at Knightsbridge, made himself known in the early twenties by the publication of several well-written works on the Heaths and the Geraniums.

The administration of J. L. Wheeler was on the whole somewhat uneventful; things went on rather by routine, and the Apothecaries' Company was called upon each year to make good a substantial deficit in the revenue.

The herborisings were continued all the time, but they became more and more difficult to organise as the boundaries of London extended outwards, and when Wheeler resigned they came permanently to an end.

By a sudden accession of good fortune in 1834 Wheeler became a man of independent means. His heart was not very much in his work, his tastes lying rather in the direction of chemistry and materia medica, in which subjects he lectured for many years in a private medical school in London. He seized the opportunity to retire from Chelsea.

In 1835 his successor was appointed—Professor G. T. Burnett, the Professor of Botany at King's College, taking his place. Burnett was an old Chelsea student, who had been trained under Thomas Wheeler. He made no mark at the garden, for early struggles with poverty and adverse circumstances had made such inroads upon his health that he died in the same year. The examination at the close of his course was conducted by David Don, a son of the Scottish botanist George Don, to whose career allusion was made in the last chapter. Don was at the time librarian to the Linnean Society, and he became Burnett's successor in the Chair at King's College His life, too, was short, as he died in 1841.

Lindley

Lindley's tenure of the professorship at Chelsea, to which allusion has already been made, immediately succeeded Burnett's death. His indomitable energy made the early years of his control remarkable. He set about a thorough reform of the whole institution, and despite much opposition from his subordinate, Anderson, the gardener, succeeded in revolutionising the whole system. At the outset he systematised the teaching, lecturing twice a week during May, June, and July, compressing the old five months' teaching into three, and making it consequently more coherent. He thoroughly overhauled the garden, and soon began its re-arrangement. His first report on the conditions he encountered on taking office told the Court that he found no catalogue of the trees and shrubs, no catalogue of the glumaceous and umbelliferous plants, and a very bad one of the other herbaceous plants. The only one that was of any value was that of the medicinal plants, and there were so few of these that the whole group was of little value. He applied accordingly as a first measure for the appointment of an assistant, to put these catalogues

in order. The Court accepted his proposals, and awarded £25 for the purpose.

Two years later he reported on the condition of the garden, showing how years of neglect had thrown it into a very bad condition, and had rendered the collections of plants of very little use. Again the Court agreed to act on his advice.

But he was soon confronted with a more serious difficulty. The old traditions of Chelsea were Linnean ; the Linnean system was firmly established in the garden, and deeply rooted in the mind of Anderson, the gardener. Lindley's reforms were such as to involve immediately the total arrangement of the plants and the introduction of his own natural system. So that Chelsea presented the picture of the great advocate of reform confronted with the embodiment of the Linnean ideas as his subordinate. Passive opposition to the changes marked the relationship from the first—opposition which became active and was soon marked by bitterness and insubordination. Lindley appealed to the Court at an early stage of the controversy, but in spite of the issue of orders from that body to the gardener, matters continued to grow more and more strained, till in 1838 Lindley had to report that little had been done, and that Anderson would do nothing, and that consequently it had become necessary that the Court should say once for all who was to be supreme, professor or gardener. It was a very unfortunate controversy, but it ended, as it was inevitable it should, by the Apothecaries' Company taking a very firm attitude and endorsing Lindley's plans. Anderson gave way, and peace was restored. Though Anderson's attitude was much to be deprecated it should not be forgotten that he had been trained all his life on Linnean lines, and that he was at the time upwards of seventy years of age, a time of life at which few men take kindly to radical changes. Anderson continued to hold his post till his death in 1846, long before which Lindley had reduced things to order and prosperity, and the natural system was fully established at Chelsea.

Between 1836 and 1853 the examinations were conducted by Nathaniel Bagshaw Ward, better known as the inventor of the Wardian cases.

Burnett

Reference has been made in passing to two botanists who were associated with Chelsea, but whose principal work was done elsewhere. In the early struggles in which the University of London

was concerned, there was a great rivalry between its two constituent colleges, University and King's. Though associated in some degree to constitute the University the authorities of both seem to have regarded their independence as more desirable than co-operation, and consequently their teaching staff was frequently doubled unnecessarily. Botany was one of the chairs affected. Lindley was made Professor at University College in 1829, and King's, not to be out-done, founded a Chair only two years later. The first Professor was Gilbert Thomas Burnett, a descendant of the celebrated Bishop Burnett. He was the son of a medical man, and in his early training he was brought into contact with the Apothecaries, serving an apprenticeship at their hall. Studying under the auspices of the Company he was thrown into the society of Thomas Wheeler, to whom his botanical training was due. He was very keen in his attendance at the herborising excursions and became one of the more marked of the younger men. Consequently, on the establishment of the Chair of Botany at King's College, he was elected to fill it. Unhappily, he suffered from very bad health, and throwing himself as he did into the duties of his profession with great enthusiasm his strength soon failed him. In 1835 he was made Professor at Chelsea, as we have seen, but died worn-out during the same year.

Burnett was the author of a work which he called *Outlines of Botany*—a very modest title, for the book contained a scheme for classification of plants according to a natural system.

David Don

Burnett was succeeded at King's in 1835 by David Don, the younger of the two sons of the Scottish botanist George Don, of whom we have spoken in a previous chapter. Don held the chair for seven years. He was born in Forfarshire in 1800, and after spending his youth as a gardener, he made his way to London in 1819, with an introduction to Robert Brown. He first secured employment at Chelsea, but was soon made keeper of the herbarium and library of Lambert. Introduced almost at once to the Linnean Society, he became librarian on the resignation of Robert Brown in 1822. In 1835 he succeeded Burnett at King's, as we have already noticed, and he retained the chair till his death in 1841. He was interested especially in the problems of taxonomy and contributed more than fifty memoirs to the general

literature of the subject. His chief work was the *Prodromus Floræ Nepalensis* which he published in 1825.

Don's elder brother George also made his way to London, and was at Chelsea for a few years, but after a time was sent by the Royal Horticultural Society, as a collector, to Brazil. He subsequently took a leading part in the publication of the later editions of Loudon's books. He is to be remembered particularly as the author of *A General System of Gardening and Botany*, a work which, based on Miller's great *Dictionary*, appeared in the years 1832-38.

CHAPTER XXXVIII

BOTANY AT CAMBRIDGE UNDER HENSLOW, 1825–61

During the later years of the last period, the study of botany at Cambridge had dwindled almost to extinction. Professor Thomas Martyn had grown very old, and, residing as he did at Pertenhall, had been for several years unable to give his course of lectures at the University. His increasing infirmities had robbed him of the enthusiasm for teaching which he had possessed as a young man, and all his efforts to find a suitable deputy, as we have seen, had failed. For some years there had been no botanical teaching at Cambridge, and there seemed no hope of any so long as the aged professor should survive.

There was residing at Cambridge at this time a young naturalist, who though showing no particular preference for botany over other branches of natural history, was held to be his probable successor, an appointment which was, indeed, the object of his ambition. This was John Stevens Henslow, a member of St. John's College, who was an ardent devotee of the study of nature, a mathematician of fair standing, and a man held in high esteem by the leading men of the University, for his character and attainments.

Henslow was born at Rochester in Kent in 1796, and was a grandson of Sir John Henslow, chief surveyor to the Navy. He showed from very early years a great fondness for natural history, and while at school was especially active in making a collection of all kinds of specimens. He entered St. John's College in 1814, and in due time graduated, being sixteenth wrangler in 1818. At Cambridge, besides mathematics he studied such natural sciences as were taught in the University and became on terms of acquaintance with Clarke, the Professor of Mineralogy, Cumming, the Professor of Chemistry, and Sedgwick who held the Chair of Geology. With the latter he worked with some assiduity, accompanying him on a geological tour to the Isle of Wight in 1819. In the long vacation of that year he visited the Isle of Man with a party of pupils.

On his return to Cambridge, Henslow, with the leading scientific men of the University, founded the Cambridge Philosophical

Society, its first meeting being held in the museum of the Botanic Garden on December 13, 1819, and its object set forth in the following terms: "That this Society be instituted for the purpose of promoting scientific enquiries, and of facilitating the communication of facts connected with the advancement of philosophy and natural history." Professor Sedgwick became one of the first secretaries. It need hardly be said that the records of this society present an account of the progress of science in the University to the present day, and that the roll of its membership includes the names of almost every one of scientific eminence, who has been trained at Cambridge since the time of its foundation.

Henslow's studies for a few years after taking his degree were principally geological. In 1821 he made a most elaborate survey of the Isle of Anglesea, mapping it, describing its physical features and its geological peculiarities, publishing the whole in the *Transactions* of the Philosophical Society on his return—a work which secured for him a high reputation as a geologist.

It was in this year that Martyn attempted to get him recognised as his deputy, that he might take on the charge of the botanical teaching, a project that, however, did not meet with success. He had not at this juncture achieved any great position among botanists, but from thenceforward he devoted himself more energetically to it, studying particularly the plants of the Fens.

In 1822 a vacancy occurred in the Professorship of Mineralogy, and Henslow became a candidate for the Chair, and after some rather unpleasant disagreement between the Senate and the Heads of Houses, he was declared elected. The matter was, however, held open for some time, and certain legal questions connected with the mode of election were not settled till 1827. Though the validity of his claim to the Chair was disputed, he discharged its duties for three years.

In 1825, as we have already noted, Professor Martyn died, and the Chair of Botany became vacant. Henslow had looked forward for many years to holding this Professorship, and had, indeed, for a long time, devoted himself to making good his qualifications. He was appointed Martyn's successor without opposition, and he held the Chair for the remainder of his life. As we have seen, Martyn held the University Professorship together with the Regius Chair which had been specially created for him. The dispute about the mode of election to University Chairs, which was raised on Henslow's election to the Professorship of Mineralogy was held to apply also to the University Professorship of Botany,

which was consequently kept in abeyance, and Henslow held the Regius Chair only, this being a Crown appointment. The Governors of the Botanic Garden gave him the post of Walker Lecturer, also vacant by Martyn's death. He resigned the Chair of Mineralogy in 1828.

It seems rather strange at the present day to find the same person holding two Chairs in subjects so little cognate as Mineralogy and Botany, or to think of one being sufficiently eminent in the two sciences to justify his application for a Professorship in each. It would not be possible now, as specialisation is so advanced; but there were fewer men of science in 1825, and the borders of any single subject were much more contracted than to-day. It must, however, be taken as an indication of the great versatility that Henslow showed, to find even so long ago that both Chairs were at his disposal. He spoke in after years of his feelings on taking charge of the Chair of Botany, admitting that [1] "when appointed to it, he knew very little, indeed, about botany, his attention having before that been devoted chiefly to other departments of natural history," adding however, that he "probably knew as much of the subject as any other resident in Cambridge."

He threw himself with conspicuous energy into his new duties. For many years there had been no lectures, Martyn being non-resident, aged, and feeble. He had given his last course in 1796, and then had said that there was so little interest taken in the subject that it was difficult to form a class. By the time of Henslow's appointment the Linnean system, of which Martyn had been so firm an adherent, was passing away before the advance of the views of De Jussieu and De Candolle, and a new vitality was beginning to be manifest. Henslow's lectures were attractive and popular; he used copious illustrations, prepared by himself, and added to the lectures demonstrations of morphology and structure from actual specimens. The students dissected these each for himself, so that we meet here for the first time in Cambridge the germ of the laboratory practice of the present day. The attendance at his lectures for the first seven years of his professorship was not less than sixty to eighty active students, a very large number for the time.

Henslow found other work awaiting him, which was almost as pressing as his actual teaching. The botanic garden which had been established with so much difficulty had fallen into a very

[1] *Memoir of Professor Henslow* (Jenyns), p. 35.

bad state, and its Governors seemed to be perfectly contented that it should remain so. He said that when he entered on the duties of his chair it was in a very neglected condition, "utterly unsuited to the demands of modern science." It was in the heart of the town, the soil was bad, and there was no possibility of enlarging it. Only a limited number of species could from its size be cultivated in the open ground, and the greenhouses and stoves were small and few in number. Apparently nothing had been done to it for very many years. Henslow often reported its inefficiency to the Governors, but it was several years before he could overcome their apathy and get any improvement. In 1831, however, an opportunity occurred and the University was enabled to purchase about 30 acres of ground on the Trumpington Road, on which to lay out an entirely new garden. Years, however, elapsed before it was in a condition to receive the plants, a matter of great disappointment to the professor. In 1846 he published an "Address to the Members of the University of Cambridge, on the expediency of improving, and on the funds required for remodelling and supporting, the Botanic Garden." In this tract he claimed that the garden ought to be "raised to a level with some other establishments of the same kind," observing "that the larger the number of living species that are cultivated in a Botanic Garden the greater will be the facilities afforded not merely for systematic improvement, but for anatomical and other experimental researches essential to the progress of general physiology. It is impossible to predict what particular species may safely be dispensed with in such establishments, without risking some loss of opportunity which that very species might have offered to a competent investigator, at the exact moment he most needed it. The reason why a modern Botanic Garden requires so much larger space than formerly, is chiefly owing to the vastly-increased number of trees and shrubs that have been introduced during the last half-century. The demands of modern science require as much attention to be paid to these as to those herbaceous species which alone can form the staple of the collections in small establishments."

It is clear from this that Henslow had a proper appreciation of the part played by a botanic garden at once in the teaching of the subject and in the advancement of botanical science by scientific investigation.

With a view to the laying out of the new garden and the proper development of the land allotted to it, he had studied the arrange-

ments at Kew, then recently placed under Sir W. J. Hooker, and had availed himself of the advice of that prince of gardeners, Lindley, setting before himself the project of making the Cambridge garden a rival to those at Edinburgh, Glasgow, and Dublin.

In the actual laying-out of the garden he was assisted by several Cambridge men, including Babington, who ultimately succeeded him in the professorship. The latter had arranged the European plants for the Edinburgh Botanical Society. Henslow secured as curator a Mr. Murray, who helped him in determining the arrangement of the garden, but who, unfortunately, died in 1850 almost before things were established. The first tree was planted in October 1846 by Dr. Tatham, the Vice-Chancellor.

During these twenty years Henslow effected great changes in the position of botany in the University. In addition to the development of the teaching to which we have alluded, he re-introduced the practice of conducting botanical excursions, which were attended by large numbers of his pupils.

He made but few contributions to botanical literature. He published a syllabus of his lectures in 1828, and a *Catalogue of British Plants* the next year. Then came a long period of literary inactivity except for the publication of some few memoirs. In his later years he brought out a *Flora of Suffolk*, which appeared in 1860. A work of less importance was his *Dictionary of Botanical Terms* published in 1857.

It was not as a writer, however, that Henslow made his mark. His skill as a teacher was what gave him his reputation, and by it he revived the fame of Cambridge as a botanical centre. He led his pupils not only to collect and to recognise specimens, but to study their relations to their environment, their functions, and particularly the great problems connected with geographical distribution and its causes. So in his hands botany became a living science.

Of his early private life in Cambridge a few words must be added. In 1823, soon after his election to the Chair of Mineralogy, he married, and in the next year was ordained—taking a curacy at St. Mary-the-less ; in 1832 he was presented by Lord Brougham, then Lord Chancellor, to the living of Cholsey-cum-Moulsford, a preferment which enabled him to continue to reside in the University for the greater part of the year.

During these years he made his house the centre of scientific society in Cambridge, receiving once a week all who took an interest in natural history studies. So important did these

reunions become that when he left Cambridge the Ray Club was organised to take their place.

In 1837 Lord Melbourne presented him to the living of Hitcham in Suffolk, a preferment of considerable value. He stayed two years longer in Cambridge, but in 1839 he took up his residence in his parish, coming to Cambridge to lecture during the Easter term in each year. He continued to discharge the other duties of his Chair as well as the difficulties of non-residence permitted, but was compelled to rely greatly on his subordinates. Of these his greatest helper was his old pupil and ultimate successor, Babington, who gradually became the leading figure in the botanical world at Cambridge.

Charles Cardale Babington was born at Ludlow in 1808, and after a short stay at Charterhouse was educated at a private school at Bath, coming subsequently to St. John's College, Cambridge. Always from his youth fond of botany he became Henslow's friend and helper from his first year of residence in 1826. Even in his early years he gave evidence of being in earnest in its pursuit. While at Bath he made diligent study of the flora which took shape in the publication in 1834 of his *Flora Bathonensis*. The work was noteworthy as indicating the lines of his future work, for it contained critical notes and references to continental floras, a comparison of which with the plants of England, had always a fascination for him.

No doubt his friendship with Henslow, and the fact that he was able to take a share in his professorial work, had a great influence on his future career. His tastes were hardly formed when he went to Cambridge, for he had a strong leaning to entomology.

Taking the turn he did, and indulging to the full his botanical tastes, it is not surprising to find him an earnest worker in the exploration of the country. His indefatigable zeal and industry in this direction remind us indeed of Ray, so many years before. So thorough was his work that he was familiar in minute detail with the topography especially of Cambridgeshire, and found little difficulty in his later years in directing his pupils to the locality of all the county rarities even to the limits of a particular field or hedgerow.

He did not travel much beyond the limits of the British Isles, but year by year he worked over some new district. He visited the outer Hebrides in 1841, in company with Hutton Balfour, and five years later he undertook a botanical tour in Iceland.

His investigations led him further, however, than the limits of a mere collector, for he had the scientific spirit in him. In this particular he at that time far exceeded his teacher and friend. It was unhappily the fact that after the Napoleonic wars England became almost completely isolated from the Continent, and between English science and the discoveries in France and Germany a great gulf had come to exist. We, in England, were ignorant of the progress that had been made in the field of botanical discovery, and it was almost impossible to identify the new plants continually being discovered, with the species detected and published on the Continent. Moreover the natural system was having free play there for its natural development, while we in England were still under the thraldom of the artificial scheme of Linnæus.

Babington was quick to appreciate this position, and feeling that it was a certain obstacle to botanical development in England set himself to attempt a remedy. The text-books of the time were few and bulky, and being for the most part Linnean in their arrangement, served to maintain our isolation rather than to minimise it. So Babington addressed himself to the task of preparing a new text-book or British flora, which should pave the way to a better state of things. It was in 1835 that he began the work, and he pursued it steadily till 1843, when he was able to bring out his *Manual of the British Flora*, a work which has been said to have revolutionised the study of British plants, and to have given an impetus to thought and work among British botanists to a degree unequalled by any publication of the century. With the exception of the fifth edition of Hooker's *British Flora*, which appeared in 1842, it was the first complete handbook of British plants arranged on the natural or De Candollean system. It brought our literature into line with that of France and Germany, and so enabled comparison to be made in detail between the floras of the three countries.

Looking at it in passing as it affected the English student, it may be said to have been extremely accurate in minute detail ; the diagnoses of genera and species needed little or no amplification.

It met with no rival till it had passed through four editions, when in 1856 Bentham's *Handbook of the British Flora* was published. This was a rival which attacked it in a point which its author considered almost vital. There was a somewhat sharp division among field botanists at that time as to the limits of species, some uniting under the name a wider range of forms than

others, who preferred to call many of the latter only varieties. It was, of course, almost an academic question, but controversy in some cases was very acute. Bentham was one of those who reduced the number of species, giving to many of them a large range of varieties. Babington was equally in earnest on the other side. He said: "An attempt has recently been made greatly to reduce the number of our native species. The results obtained seem to be so totally opposed to the teaching of the plants themselves, and the evidence adduced in their favour is seldom more than a statement of opinion, that they cannot safely be adopted; nor does the plan of the present work admit of discussion of the many questions raised by them. Also it has been laid down as a rule by some botanists that no plant can be a species, whose distinctive characters are not as manifest in a herbarium as when it is alive. We are told that our business as descriptive botanists is not 'to determine what is a species,' but simply to describe plants so that they may be recognised from the dry specimen. The Author cannot agree to this rule. . . . It seems to be our business to decide upon the probable distinctness of plants before we attempt to define them; to make the species afford the character, not the character form the species." On such grounds he advocated a somewhat generous application of the term "species."

In preparing his diagnoses, Babington made a careful study of all difficult genera, by means of the books and fasciculi of dried specimens that had been published by the critical botanists of the Continent, thus carrying out the plan which he had at the outset set before himself. Among the genera and sub-genera which he revised may be mentioned *Atriplex*, *Arctium*, *Fumaria*, *Batrachium*, *Cerastium*, *Dryas*, *Armeria*, *Saxifraga*, *Hieracium*, *Potamogeton* and *Rubus*. In the last-mentioned genus he took a special interest throughout his whole life, and from the extensive study he made of the British forms in particular he became the leading authority of the time upon all questions of the delimitation of its species. During Henslow's life he was engaged in researches upon the genus, with the result that he was able to publish in 1846 his *Synopsis of the British Rubi*—a forerunner of a larger work which appeared during his subsequent tenure of the professorship.

During this period of his life Babington achieved considerable distinction as a botanist, which was recognised by his election to the Fellowship of the Royal Society in 1851.

During the latter years of Henslow's residence at Hitcham,

Babington was engaged in the preparation of his *Flora of Cambridgeshire*, which he published in 1860. This was the only list of Cambridgeshire plants which appeared after Relhan's book. It was, of course, written on altogether different lines, the Linnean arrangement having long been superseded by the natural system. The book, too, was far wider in scope ; it was not merely a catalogue of plants—he dealt with problems of geographical distribution, tracing the appearances of different species through the different districts of the county. He also passed under review the changes in the vegetation of the fens that had been caused by the extensive system of drainage which had been carried out.

So during the peaceful years of Henslow's life which followed his retirement to Hitcham, matters progressed satisfactorily if slowly. He continued to give his lectures and to take a certain share in the general working of the University. In the agitation which led to the inclusion of natural science among the studies leading to the conferment of a degree he took a great interest. This desirable change was very difficult to secure. The Natural Science Tripos was established in 1851, but it was not till ten years later that it qualified for the degree.

Henslow was, above all things, an educationist, and made a reputation for both teaching and examining. He was one of the first examiners for the new tripos at Cambridge, and served in the same capacity for twenty-two years in the newly established University of London, of the Senate of which he was an original member under the Charter of 1836. As a teacher he was masterly in his treatment of his subject, and had as great a control of village children as of university students. He devoted himself with much earnestness to cultivating a taste for the study of nature among his people in his country parish, and his influence in that direction spread through the whole county of Suffolk. His appreciation of botany as a mental discipline was expressed in an address he gave in 1846 when making an appeal to the members of the University on behalf of the new botanic garden. "I must consider the claims of botany are not sufficiently appreciated among us. There are persons of great mathematical and classical attainments, who have very erroneous notions respecting the ultimate aim and object of this science. Many persons, both within and without the universities, suppose its objects limited to fixing names to a vast number of plants, and to describing and classing them under this or that particular 'system.' They are not aware that systematic botany is now considered to be no more

than a necessary stepping-stone to far more important departments of this science, which treat of questions of the utmost interest to the progress of human knowledge in certain other sciences which have been more generally admitted to be essential to the well-being of mankind. For instance, the most abstruse speculations on animal physiology are to be checked, enlarged, and guided by the study of vegetable physiology, without continued advances in this latter department of botany the progress towards perfection in general physiology must be comparatively slow and uncertain. As regards the progress of botanical physiology, even chemistry itself must be viewed as a subordinate assistant, whilst it is making us acquainted with those physical forces by which mere brute matter is regulated and arranged. Those forces are themselves to be restrained and modified by the instrumentality of vegetable life, in bodies whose appointed position is to prepare all the organic matter that is destined for the support of a still higher race of creatures in the general scheme of nature. We may feel quite confident that some of the arts we consider to be most important to man, such as agriculture and horticulture, will never be perfected until the fundamental properties of vegetable physiology shall have been satisfactorily elucidated. Numerous, indeed, are the bearings, direct and indirect, which botany holds upon other sciences, and upon various arts!"

Apart from his teaching work, Henslow exerted a considerable influence on contemporary thought. He was extremely active in the work of the British Association for the Advancement of Science; he occupied the Chair of the Natural History section four times, the last being at the memorable meeting at Oxford, when the views on the *Origin of Species* which had recently been promulgated by Darwin and Wallace, were discussed under his presidency.

He took much interest in the application of science to agriculture, and while at Hitcham did a great deal to persuade the local farmers to co-operate with him in submitting various problems to the test of experiment. It was to him that we owe the discovery that the so-called coprolites contain 56 per cent. of phosphate of lime and are of great value as a fertiliser. He was the first to detect as long ago as 1841, that the uredospores borne on the grasses belong to the same fungus as the æcidiospores found on the barberry—so showing the heterœcism of *Puccinia*.

It must not be overlooked that in large measure science owes the career of Darwin to the influence of Henslow. He was the means of securing for him the scientific work on the *Beagle*, which was the starting-point of his wonderful investigations. But to this reference will be made in a subsequent chapter. The career of Berkeley the great mycologist also was in large measure the result of the influence of Henslow.

Henslow continued to hold the living of Hitcham for twenty-four years. Comparatively unobtrusive as his work was, he did more than any man of his time in England to advance botanical study and to arouse an interest in it among the people generally. He possessed the rare ability of exciting enthusiasm in the minds of his pupils, and thus he popularised the subject wherever he went. For the last five years of his life his physical powers showed signs of declension, and after an illness of about two months' duration he died in 1861.

He was succeeded in his Professorship by Babington according to general anticipation.

CHAPTER XXXIX

SUBORDINATE FEATURES OF THE PERIOD

THE study of physiology was quite overshadowed in England during these years. After the investigations of Knight only isolated researches appeared. Among them may be noted the following facts. In 1827 Burnett and Mayo discovered the sensitiveness to contact of the under surface of the pulvini of *Mimosa pudica*, and made the further observation that such sensitiveness is strictly located there. In 1834 Curtis discovered that the appreciation of contact shown by the leaves of *Dionæa muscipula* is confined to the hairs on their upper surfaces. In the same year Brewster showed that an alcoholic extract of green leaves presents a characteristic absorption spectrum, pointing thus to the discovery that the sunlight affords energy to the plant, a fact of extreme importance, as the general phenomena of photosynthesis were not then understood. In 1843 Draper in his researches on the solar spectrum came to the conclusion that the rays most active in this process are the orange and yellow, a conclusion which was not in full accord with the deductions made from Brewster's work, and which led to considerable controversy, till the discrepancy was explained by Timiriazeff several years later.

Another feature of the early part of the nineteenth century which grew more and more important as time went on, was the influence exerted by publications of learned societies which were formed almost continuously and the great increase of periodical literature originated by leaders of botanical science. The necessity for writing large volumes such as those of Grew, Hales, Knight, and others, ceased to be felt, and an author communicated his discoveries or the results of his explorations in some periodical form, or as a contribution to the *Transactions* of some society. Hence we find a great change coming over the literature of botany.

The commencement of this change may be associated with the foundation of the Royal Society. At first this body undertook the publication of lengthy memoirs ultimately appearing as

separate volumes recalling the works of earlier writers. Such was Grew's great work, *The Anatomy of Plants;* such, too, the communications of Malpighi. But the association of men of science for discussion at frequent intervals led to the production of shorter papers dealing only with separate points of interest, and with the number of them came the necessity of keeping all together, though their subject-matter showed considerable variety. Such aggregation of papers, of varying degree of importance, being sometimes only in a way memoranda of experiments, soon became inconvenient. New societies of more limited aim sprang up, each with its series of *Transactions* or *Journal*, in which it published what had been the subjects of interest at its meetings. Hence as time passed, the scientific journal gradually replaced the monograph as the latter had done the more exhaustive treatise which was often its writer's only contribution to literature.

Not that the master treatise passed altogether from the field. Hales's *Staticks* bears witness to the contrary. Nor was the periodical publication overlooked. Many of these had their day; they published a man's work without its having had a preliminary communication to a learned society.

The periodical literature, however, replaced almost entirely the older form of publication, and as its circulation was much larger it aided very materially in the dissemination of knowledge.

Reviewing the progress of taxonomy during the first half of the nineteenth century, we see how gradual was the change which was effected by the labours of so many workers—how gradually the classes of Linnæus gave way before conceptions of natural orders which took so prominent a place in the systems of De Jussieu and De Candolle. But we must not forget that even the most complete of all these schemes owed much to, indeed, were at bottom based upon the labours of Linnæus. To him we owe the conception and delimitation of genera, perhaps the most important unit in classification. Nor must we overlook the precision which he introduced into the art of description, making each species stand out with clear individuality. On this basis alone any system must stand, and in this matter all systems are related. Each is built up by a separate and individual sorting of the genera upon some principle peculiar to the classifier.

The change was not violent, though it was radical. We have seen how gradually Robert Brown undermined the general acceptance of the Linnean proposals by quietly ignoring them and substituting others; how Lindley combatted them more

openly by his writings and his teaching, devoting a long series of works to taxonomic proposals, which, if not entirely successful in their purpose of construction, yet had a large share in banishing the Linnean scheme from England. It must be remembered, too, that the continual additions to knowledge made by the explorers of exotic floras enabled progress to be made which, for lack of material, was quite beyond the powers of Linnæus. Perhaps it would only be fair to say that the influence of this factor fell rather into the succeeding period of history, when Sir W. J. Hooker inaugurated such activity in this direction at Kew. But it had already begun, and the explorations to which we have called attention in the present chapter went far to establish or to make clear the necessity for the natural system.

The Linnean system might probably have disappeared much earlier had it not been for the personal influence and work of Sir J. E. Smith, who was always loyal to the great Swede, of whose collections he was the custodian as President of the Linnean Society for so long a period. It was no slight task to dislodge the artificial system from literature and from the British and local floras, which had been written prior to 1820.

Loudon

A few other figures of some note call for some notice during this period, though they were only of minor importance. A somewhat famous person was John Claudius Loudon, an eminent landscape gardener and writer on horticultural subjects. Born in 1783, he came to the metropolis at the age of twenty, with something of a reputation, and was admitted to the Fellowship of the Linnean Society in 1806. His knowledge of gardening was the result of study on the Continent as well as in England, for he had travelled a good deal, even visiting Russia. His reputation rested at first on his *Encyclopædia of Gardening*, which he published in 1822; it was, of course, a compilation, but it was well done, and met with immediate success. He followed it up with the *Encyclopædia of Agriculture* in 1825, and the *Encyclopædia of Plants* in 1829, both of which were exhaustive. He started the *Gardeners' Magazine* in 1826, and the *Magazine of Natural History* two years later.

His most valuable production was the *Arboretum et Fruticetum Britannicum*, which he brought out in 1838 in monthly parts. Unfortunately, the publication was unsuccessful, and involved

him in heavy financial loss, from which he never completely recovered. It deserved a better fate, for no less an authority than Sir W. J. Hooker was greatly impressed by its value. He said of it: "There is not a naturalist in Europe who could have executed the task with anything like the talent and accuracy displayed by Mr. Loudon."

His last *Encyclopædia*, that of trees and shrubs, appeared in 1842. It was practically an abridgement of the *Arboretum*. Besides his books he was known to his contemporaries by his success in practical horticulture. He laid out the botanical gardens at Birmingham in 1831, and the arboretum at Derby in 1839-41. He died in 1843.

Johnson

Charles Johnson's name is associated with this period. He was made lecturer at Guy's Hospital on the foundation of its medical school in 1830, and in 1832 he rearranged Smith and Sowerby's *English Botany* for its second edition. This appeared in twelve volumes, between 1832 and 1846. Johnson's other contributions to botanical literature were: *Ferns of Great Britain* (1855), *British Poisonous Plants* (1856), and *Grasses of Great Britain* (1861).

Herbert

Another writer of this period, in his youth a contemporary with Knight, was William Herbert, subsequently Dean of Manchester. He was the third son of the first Earl of Carnarvon; he was born in 1778, and was educated at Eton and at Christ Church and Exeter Colleges, Oxford. After being for a short term in Parliament he took orders, ultimately being made Dean of Manchester. Herbert made a special study of hybridisation, communicating the results of his experiments, as Knight did, to the Horticultural Society, in whose *Journal* they were published. He carried out some important researches on certain of the Monocotyledons, his chief memoir dealing with the Amaryllideæ. He summed up his results in the statement that he believed he got better offspring from his plants when he pollinated, or, as the term was then, fertilised, a flower with pollen taken from another flower than when he employed the product of its own stamens.

Herbert's paper on the Amaryllideæ is remarkable for a statement which he made in it on the question of the fixity of species; which shows him to have entertained similar ideas to those which

ultimately took shape in the mind of Darwin, and which, as elaborated by the latter, changed the whole course of botanical study. He wrote: "horticultural experiments have established beyond the possibility of refutation that botanical species are only a higher and more permanent class of varieties." This was written in 1837. It must not, however, be taken that the Dean was a believer in evolution in the form in which it was presented by Darwin, as he held the creation of a single species for each genus.

Lambert

Another botanist of considerable distinction who played a part in the social life of the time was Aylmer Bourke Lambert, a wealthy amateur, who did much to foster the science as its development proceeded. He was born at Bath in 1761, and was educated at St. Mary Hall, Oxford. While a young man he enjoyed the friendship of Pulteney and of Lysons, and in later years was closely associated with Sir Joseph Banks and with Sir J. E. Smith. He was one of the original members of the Linnean Society, and from 1796 till his death in 1842 was one of the Vice-presidents. Though he did not write much he was a frequent contributor to its *Journal* from 1794 to 1837. His first important work was a description of the genus *Cinchona*, which was illustrated by eight species taken from Banks's specimens. He wrote also a monograph of the genus *Pinus* in two volumes, which were illustrated with coloured plates of considerable excellence. The first volume appeared in 1803, the second in 1824. The work went through several editions.

During most of the last half of his life he lived at Boyton, and being always an ardent collector he got together a herbarium of some 36,000 specimens. It included, in addition to his own collections, the accumulations of nearly fifty other botanists in different parts of the world which he had acquired by purchase. With great kindness he put the whole at the service of all botanical students who chose to consult them. David Don, afterwards librarian to the Linnean Society, was his assistant, and had charge of the collection. In 1839, however, he removed to Kew, where he died. Lambert attained some distinction; he was made a Fellow of the Royal Society in 1791, and was later elected a member of numerous foreign societies. Sir J. E. Smith styles him "one of the most ardent and experienced botanists of the present age." In his later years he became intimate with Bentham and the

other leaders of botanical thought. He died in 1842, still a Vice-president of the Linnean Society and the last survivor of the original members.

After the death of Banks, Lambert in some measure succeeded to his influence in the affairs of Kew, though he was never officially connected with the gardens, nor did he take up his residence at Kew till a few years before his death.

Griffith

This period was not characterised by so much enterprise in the matter of botanical exploration as were the years of the middle of the century. Nevertheless, the work of Robert Brown does not stand alone in the field. A very noted Indian botanist was William Griffith, an old pupil of Lindley's, educated under him at University College, London. In his early years he showed some ability in the pursuit of morphology and anatomy, but in 1832, at the age of twenty-two he went into the service of the East India Company. In 1835 he started on his first expedition with Wallich as a colleague, the object of the journey being to inspect the tea forests of Assam and to explore its natural history. He worked for many years in the east of the Indian territory, exploring as far as Burma. Later in his life he penetrated beyond the Hindu Koosh into Khorassan and Afghanistan. From 1842-44 he acted as *locum tenens* for Wallich in the charge of the Botanic Garden at Calcutta.

In the intervals of his administrative work Griffith devoted much attention to anatomical investigation. He set himself to solve many of the problems connected with the development of the ovule and the process of fertilisation, which was at the moment attracting much attention. He chose for his material chiefly a group of plants, the parasitic Phanerogams, in which much abnormality was to be expected, and greatly advanced the knowledge of these phenomena in the Santalaceæ, Loranthaceæ, and Balanophoraceæ. Subsequently he elucidated the structure of the ovule and development of the seed in the group of the mangroves, the vivipary of which had always interested him. He was an adherent of the views of Schleiden in his conception of the process of fertilisation. He devoted some attention to the morphology of the ovule and its contents in *Cycas*, and greatly extended and amplified the researches of Robert Brown. He made a reputation also for his work among the Cryptogams. As

early as 1832 he made an important investigation of *Targionia*, one of the Hepaticæ, and he followed it up later in life by researches into the origin of the sporogonium or so-called fruit, in many of the genera, which he showed to be preceded by a process of fertilisation. The genus with which he was least successful was *Anthoceros*, in which he failed to recognise the archegonia, or as he called them the *pistilla*.

He has been known chiefly by his work on the Bryophyta, and particularly the Hepaticæ, but he also paid some attention to the Pteridophyta. His observations on the morphology of the reproductive organs of *Salvinia* and *Azolla* were noteworthy, but he was not in advance of his day in explaining them. This was before the recognition of alternation of generations.

Griffith projected a general *Flora of India*, and had accumulated a large store of material. It was published after his death in 1845, but the editor into whose hands it fell allowed many gross errors to creep in, and its value was consequently greatly impaired. His manuscripts are in the library of the herbarium of Kew, together with a fine set of his plants. The elaboration of the flora of our great dependency remained for other hands to carry out much later.

Wallich

Wallich, Griffith's colleague in the Assam expedition was even more successful as an explorer. He was, like Roxburgh, a surgeon in the service of the East India Company, and was the first botanist to make collections of plants in the Himalayas and Burma. Later, he explored the flora of Nepal. He was made superintendent of the Botanic Garden at Calcutta in 1815. Invalided home in 1828, he brought with him some 8000 species which were distributed by himself in association with Bentham to public institutions and private collectors. He returned to India after a few years and then with Griffith as a companion, explored the flora of Assam. His labours proved too onerous for his health, and he returned to England finally in 1847, having resigned the active charge of the garden five years earlier. He died in London in 1854.

His chief publication was the *Plantæ Asiaticæ Rariores* which appeared in the years 1830-32. Besides this work he was associated with Curry in the edition of Roxburgh's *Flora Indica* to which we have alluded.

During his residence in England he took an active part in the work of the Linnean Society, and was a conspicuous figure in the botanical circle of the time. He was made a Fellow of the Royal Society in 1829.

The progress of the study of Palæobotany: Artis

We have seen that the earliest writer on fossil plants in England was Llwhyd, contemporary and friend of Ray and curator of the Ashmolean Museum at Oxford towards the end of the 17th century. His observations remained as a record of all that was known in this country till the beginning of the 19th century. If any records were made, they attracted but little attention and were not preserved. In 1825, however, the subject came again into prominence, and has steadily increased in importance till the present day. It was then that E. T. Artis published a work under the title of " Antediluvian Phytology, illustrated by a collection of the fossil remains of plants peculiar to the Coal formation of Great Britain." It was not an ambitious volume, being in the main a compilation of figures of what were mostly impressions of plants. No internal structure was shown in any of the plates which, however, were wonderfully well executed—indeed those of Calamites rank among the best of the early drawings. Most, if not all, the specimens described, had been found in the Yorkshire collieries, that of Elsecar yielding about half of them. The author gives as his authorities the continental writers, Schlotheim, Sternberg, Martius, and Brongniart, whose schemes of classification he quotes. It is quite evident that in this field of work England had lagged far behind her continental rivals. Artis expected to bring out an outline of a system of classification of coal measure plants in a subsequent volume, but his hopes were not realised.

Witham

Almost contemporary with Artis there appeared another writer to whose activities far greater progress was due. This was Henry Witham of Lartington, who practically founded the study of the fossils as it is recognised to-day, for he made the great advance of examining their internal structure by means of microscopic sections, instead of confining his observations to their external forms and markings. The method of cutting such sections was

first introduced by William Nicol of Edinburgh, who devised it in 1827, thereby opening up possibilities which had not so far been even dreamed of. Witham seized hold of the method, realising what an enormous advance it made possible, and he availed himself of it to conduct many valuable pieces of research.

Witham began to publish papers based on this method in 1829, when he read a memoir before the Wernerian Society of Edinburgh, and he continued to do so for a period of many years. He described his method of preparation of his sections in his *Internal Structure of Fossil Vegetables*, published in 1833, but he rested his views almost entirely on transverse sections, to the neglect of longitudinal ones, a procedure criticised later by Lindley and Hutton.

It is not possible here to give a very detailed account of Witham's researches. He held that the flora of the mountain limestones and the coalfields was partly Coniferous, though cryptogams largely preponderated. In his diagnoses he made great use of the "exogenous" structure to support this view, a characteristic which later work showed to be largely fallacious. He examined coal with great care, but except in a few instances he failed to get an insight into its structure. He thought he had ascertained the presence of Dicotyledons among the Carboniferous Flora. He challenged the statement that the palæozoic period was the age of Cryptogams, and demonstrated the early prevalence of Gymnosperms. He said that the fossil trees met with in the lias were mainly of this class.

His most important researches were those concerned with the distribution of Gymnosperms, but he made a few contributions to the knowledge of the Cryptogams which were of great importance. He was the first to describe and figure *Lepidodendron Harcourtii*, a fossil Lycopod, on which he read a paper in 1832. Lindley and Hutton writing some years later alluded to this as being, up to their time, "beyond all doubt the most remarkable discovery in the science of Fossil Botany."

Witham investigated another Lycopod, *Anabathra pulcherrima*, which shows secondary growth in thickness, helping thus to minimise the importance of this factor as a mark of the so-called Exogens (*Dicotyledons*).

His most important contribution to literature was the book already alluded to, the *Internal Structure of Fossil Vegetables*, published in 1833, in which he summed up his results and showed that the plants of the early times were at least as complicated in their

histological features as the vegetation of to-day, an advance which has opened the way to a much wider conception of the stages of evolution in the vegetable kingdom than would otherwise have been possible.

Nicol, the deviser of the method Witham utilised with such good results, was himself a contributor to the literature of the subject. He published some "Observations on recent and fossil Coniferæ" in the *Edinburgh Philosophical Journal* in 1834.

Lindley and Hutton

The work of Lindley and Hutton, to which reference has already been made, followed quickly on the discoveries of Witham. Indeed, it partly overlapped them, for the publication began in 1831 and was not complete till 1837. This work in three volumes, the *Fossil Flora of Great Britain*, was a very complete account of the sum total of knowledge of palæophytology at the time. It gave very carefully drawn figures of such of the fossils as were known, particularly of those of the carboniferous period, and elucidated their structure as fully as was possible. The authors claimed to have demonstrated that both *Sigillaria* and *Stigmaria* were plants with "the highest degree of organisation," and could be compared with the most highly specialised among the Dicotyledons of to-day.

Binney

In the course of the next decade the literature of fossil plants began to be enriched by the contributions of E. W. Binney. Born in 1812, he went to reside in Manchester in 1836, where he practised as a lawyer. His first scientific work was an investigation of the geology of the neighbourhood of Manchester, an indication of the branch of natural science to which he was originally attached. He took a share in the foundation of the Manchester Geological Society in 1838, and was a frequent contributor to its *Transactions*, writing several memoirs on geological subjects. He was soon attracted, however, to the study of the fossils, and in 1844 he wrote a memoir on certain fossil trees that had recently been discovered near St. Helens. Other papers soon followed—on a *Sigillaria* in 1846, and on the origin of coal two years later. He was, as a result of these publications, made a Fellow of the Royal Society in 1856, and for many years continued to make valuable contribu-

tions to palæobotany. In the course of these he demonstrated that all coal seams rest on old soils which were constituted largely of vegetable matter. His first contribution to our knowledge of the coal beds was made in 1858, when he read before the Manchester Geological Society a paper on *Sigillaria* and its roots. He was especially interested in the Calamites, which he studied with much diligence. He distinguished two distinct but outwardly similar types, *Calamodendron*, which he held to be a gymnospermous exogen, and *Calamites* proper. In this he followed Brongniart, to whom the distinction was originally due. It was based on the erroneous conception that secondary thickening which existed in *Calamodendron* was a mark of higher organisation than any vascular cryptogam possessed.

His later work contains some contributions to our knowledge of the fossils related to the Lycopodiales. He was a prolific writer. Besides his larger memoirs he contributed thirty-three papers to the Manchester Geological Society between 1839 and 1872, besides others to the Geological Society of London.

Robert Brown also was interested in fossils, though he made but one contribution to the literature of palæobotany. This was a paper on a strobilus, which in 1847 he described as a fossil fruit, and gave it the name *Triplosporites*. He subsequently identified it in 1851 with *Lepidostrobus*.

CHAPTER XL

CONTEMPORARY BOTANY IN SCOTLAND AND IRELAND

Hooker at Glasgow

THE departure of Graham from Glasgow brought to the front a third great figure of the botanical world of the last century—one whose influence, exerted in fields differing from those occupied by either Robert Brown or Lindley, was not inferior to that of either of them. Perhaps, in a sense, it was greater, for the institution which he developed at Kew remains to-day as important as it ever was, and bulks perhaps larger than ever in the public eye as representative of English botany.

Sir William Jackson Hooker was born in 1785 at Norwich, and received his education at the grammar school in that city. Becoming possessed at an early age of landed property in Kent, he went, at the expiration of his school-days, to study estate management under a Mr. Paul, at Starston in Suffolk, where he gave himself ardently to natural history pursuits, particularly ornithology and entomology. He made the acquaintance of the veteran naturalist, Kirby, together with Spence and McLeary. Later he formed a friendship with Dr. (afterwards Sir) J. E. Smith, the President of the Linnean Society, whose influence led him to attach himself more assiduously to botany, which had already exercised a great charm for him, and to which with such signal distinction he devoted his subsequent life. By the time he attained his majority in 1806, he was familiar with the vegetation of his native country, not only the flowering plants, but the Mosses and Liverworts, the freshwater Algæ, and the Lichens. His first botanical success was the discovery in 1805 of the singular moss, *Buxbaumia aphylla*, which had never before been found in England. It had a remarkable influence indirectly on his after life, for on his showing it to Sir J. E. Smith, the latter sent him with it to Mr. Dawson Turner, F.R.S., a well-known muscologist, whose daughter Hooker subsequently married.

The reputation which he had attained as a naturalist led to his election at the age of twenty-one to the Fellowship of the Linnean Society, he being, perhaps, the youngest person who ever received

admission. Hooker's next few years were devoted in the main to botanical exploration. He carried out in 1807 and 1808 two prolonged tours all over Scotland with Dawson Turner and with Borrer. About the same time he paid frequent visits to London, and made the acquaintance of the leading naturalists there, including Robert Brown and Sir Joseph Banks, with whom he founded warm friendships. At the instance of the latter he undertook in 1809 an expedition to Iceland. Unfortunately, on the return voyage the ship was burnt, and Hooker's collections were destroyed. On his arrival in England, however, he wrote, and subsequently published, his *Journal* of the tour. During the next three years he was continually endeavouring to visit the tropics to study the botany of various regions, but he met as constantly with disappointment. He was going to Ceylon, when a rebellion broke out there, making travel in the island impossible —then he proposed Java, but was deterred from this by the reports he received about the prevalence of malaria.

In 1814 he went for a three months' tour through France, Switzerland, and Italy, in the course of which he made the acquaintance of A. L. de Jussieu, Lamarck, and other distinguished naturalists, and during his return met Humboldt.

Returning to Norfolk, Hooker in 1815 married Miss Turner, the daughter of his old friend, and settled down at Halesworth, devoting himself to writing and collecting, laying the foundation of his great herbarium. It was during the period of his residence there that he made the acquaintance of Lindley, as mentioned in another connection, an acquaintance that ripened into a life-long friendship. To the year 1816 must be referred the publication of the *British Jungermanniæ*, which had occupied his leisure during ten years. This work is the real starting-point of hepaticology ; it appeared in parts with eighty-eight plates, illustrating 197 species, and from the excellence of the drawing and engraving of the plates, carried out by Edwards, together with the analyses of the group, must be considered the most beautiful of all his works. In 1818 he published the first volume of the *Musci Exotici*, which was followed by the second in 1820. Altogether Hooker produced four botanical works of the first importance between 1816 and 1820.

In collaboration with Dr. Taylor, Hooker published in 1818 the *Muscologia Britannica*, with illustrations of 300 species, nearly all collected by the authors during the preceding eight years. It contained as well an analytical table.

In 1819, as we have seen, Graham vacated the Professorship of Botany in Glasgow. Though he had had no experience of university life and no practice in teaching, Hooker was next year elected to succeed him after Robert Brown had declined the chair. The great reputation he had attained had made it difficult to pass him over on his announcing a candidature, but the active support of Sir Joseph Banks was no doubt a factor in the choice. It was, indeed, at Sir Joseph's suggestion that Hooker came forward, a step fraught with momentous consequences alike to Glasgow and to botany in general. At the time the emoluments of the chair were only about £60 a year, and the number of students only fifty. There was the prospect of arduous departmental work before the new professor ; the garden was newly established and remained in need of solicitous care, and the burden of developing the school against a good deal of apathy and not a little opposition was no light one. To say that Hooker entered upon it with a light heart would be to misrepresent his attitude, but he grappled with the difficulties with characteristic courage, formed his plans with wisdom, showed indomitable energy in carrying them out, and so succeeded in developing both garden and university department in a manner which by itself marked him out as possessing a genius for organisation and university work.

On Hooker's arrival at Glasgow he met with a cordial reception from his new colleagues, and was installed into his chair with great promptitude. The degree of LL.D. was conferred upon him almost at once. He took up at the outset the duty of teaching, having, owing to his inexperience, to devote much time to the preparation of his lectures. We have already noticed how, under Professor Hamilton, the subject had been treated comprehensively and thoroughly, and there is no need to suppose that under his successors the tradition had been lost. Hooker had had but little familiarity with the physiological and anatomical aspect of botany, nor with the point of view in vogue at Glasgow, where the subject was treated mainly from the medical side, the kinship between it and materia medica being insisted upon as a basis of study. In Scotland, generally, at the time, the influence of Hope's teaching had not died out, and the Linnean system of classification was still prevalent. With this he had little sympathy, as we may imagine when we call to mind his relations with De Jussieu, De Candolle, and other champions of the natural system. Like Robert Brown, he treated the Linnean system not so much with active opposition as with neglect. He was obliged to teach it,

but he published for the use of his class the *Flora Scotica* of 1821, in which both systems, however, were introduced for purposes of comparison, and to enable the new teaching to be accepted by the adherents of the old. He soon became a very successful lecturer: his pupils increased in number, nearly trebling during his tenure of the chair. For fifteen years he gave his annual course of lectures from May to July, holding the class in the gardens. Subsequently he gave an additional course in the University buildings during the winter. He was in favour of work in the field as well as in the garden, and every year organised and conducted excursions, in which he accompanied his students, after the manner of the Chelsea herborisings.

To Hooker the new Sandyford garden was especially indebted for a great measure of its success as a scientific institution. The species under cultivation grew from 9000 in 1821, to nearly 20,000 in 1840, many of them altogether new. By the end of his directorship the garden could be compared favourably with most of its contemporaries. Bower says: "It is noted in the minute books that at this time scientific visitors to the garden almost invariably expressed the opinion that the garden would not suffer by comparison with any similar establishment in Europe." Hooker showed at Glasgow the wonderful power of organisation which was so conspicuous a feature of his work afterwards at Kew.

Apart from his university work he laboured very assiduously in his herbarium and at his desk, often working for sixteen hours a day. His publications during the period of his professorship were very numerous. Among them may be mentioned several volumes of the *Icones Plantarum* which ultimately occupied ten volumes (1827-54), with about 1000 plates, *Icones Filicum* (with Greville) in two volumes (1829-31); the *British Flora* two volumes, (1830-31) with four subsequent editions before 1842; together with many volumes of periodicals, the issue of several of which was continued long after he left Glasgow, and many works of smaller dimensions. His herbarium was all the while an object of his care, indeed before he gave up his professorship his herbarium and library were reckoned as among the richest private ones in Europe.

Among the friends and collaborators who worked with him at Glasgow were Greville; Geo. Bentham, later one of the authors of the *Genera Plantarum*; Richardson, the Arctic explorer; Walker-Arnott, one of his successors in the Chair of Botany; Wilson; Berkeley, the fungologist; Watson, and W. H. Harvey, Professor

in Dublin, the leading authority in after years on the subject of the Algæ. Bentham's first visit was in 1823, and from it he dated his own permanent adhesion to botany.

It is not surprising that he was marked out for distinction at the hands of the government. In 1836 William IV. made him a Knight of Hanover for his great services to botanical science. It may be said that he had previously more than once declined the honour of knighthood.

The incidents of his public career at Glasgow were not very conspicuous. His success as a teacher was recognised in 1826 by his salary being raised to £150 by the appropriation to it of the £100 previously paid annually to the University under the old gift of Queen Anne. He had to fight hard for the adequate recognition of botany in the medical school, a sharp controversy lasting all the time he was at Glasgow on the question of fees and recognition of courses outside the University as qualifying candidates to present themselves for the M.D. examination.

Though working so efficiently at Glasgow, Hooker felt himself far from the centre of the scientific world in England, and for many years he looked longingly towards Kew as his ultimate goal. Under circumstances which are discussed more fully elsewhere his hopes were ultimately realised, and in 1841 he was appointed Director of the Royal Gardens on the resignation of W. T. Aiton, and the transfer of the establishment from the Lord Steward's Department to the Commissioners of Woods and Forests. To the great loss of Glasgow he resigned the Chair of Botany at once.

Greville

This period was made noteworthy in Scotland by the activity of one who has been held to have done more than any other botanist of recent times in the field of cryptogamic botany, R. K. Greville, the friend of Hooker, Graham, and the other leaders of botanical science in Britain. He was born in 1794 at Bishop Auckland, and settled in Edinburgh in 1816. A botanist from his youth, he devoted himself in the main to the study of the Cryptogams, and in 1823 began to publish in monthly parts the *Scottish Cryptogamic Flora*. The publication extended over six years, and the work contained 360 plates. Another work from his pen was the *Flora Edensis* of 1824, which included the Phanerogams as well as the Cryptogams of the district. These two publica-

tions led the University of Glasgow to confer on him the degree of LL.D.

His friendship with Hooker led to their collaboration in the publication of the *Icones Filicum* already alluded to. Two folio volumes appeared in 1829 and 1831; they contained 240 plates drawn and coloured by himself. The ferns were largely Wallich's Indian species together with other exotics. In 1830 he published a large work on the British Algæ.

Apart from these efforts of the pen, Greville was well known as an ardent explorer and collector, chiefly investigating the Scottish Highlands. In his wanderings he amassed a very large collection.

In 1862 he was awarded the Neill Medal by the Royal Society of Edinburgh for his work on Diatoms.

After his death in 1866 his Algæ were presented to the British Museum, his other Cryptogams to the Edinburgh Botanic Garden, and his flowering plants to the herbarium of the Glasgow University.

Greville's name is commemorated by the title of the chief English magazine devoted to cryptogamic botany, *Grevillea*, now extinct.

Borrer

Another name that must be mentioned in connection with Hooker's life at Glasgow is that of his friend and correspondent, George Borrer, an amateur botanist of much ability. He wrote the descriptions of the species of *Myosotis* and *Rosa*, and many of those of *Rubus* for Hooker's *British Flora* of 1830, and he collaborated with Dawson Turner in the preparation of the privately printed *Lichenographia Britannica*. He published but little apart from these works, but he amassed a considerable herbarium, which after his death was sent to Kew.

Graham at Edinburgh

Naturally during this period the activities manifested at Glasgow threw the course of events at Edinburgh into the background. There were, however, changes and developments taking place there that had a very great influence upon the progress of botanical science in Scotland. Professor Robert Graham was a very different person from his predecessor. He was in the prime of life, and after an arduous struggle in Glasgow had achieved

conspicuous success, following Jeffray in the Chair of Botany. At once he found himself engaged in the important task of laying out and developing a new botanic garden, which if not very extensive laid sufficiently onerous duties upon him. He had hardly established his position before he found himself called, in less than two years, to the even more dignified position of Regius Professor of Botany at Edinburgh, and Keeper of the King's garden, the appointment dating from 1819. As we have seen the chair was first offered to Robert Brown, who declined it. Sir James E. Smith was Graham's rival for the professorship, but the claims of nationality in this case prevailed. In the next year the Town Council elected him Professor of Medicine and Botany, the post which they had originally given to Alston many years before. By a strange coincidence his attention was again immediately called to the question of the botanic garden, and his energies engaged on its removal to a new site. This transference was, however, on a much larger scale than had been that at Glasgow.

As soon as he found himself face to face with the questions presented by his new sphere he discovered that the maintenance or removal of the garden was a problem under discussion by the government and the authorities at Edinburgh. The grounds at Leith Walk were becoming more and more inconvenient, owing to the rate at which the city was being extended in a northerly direction. The government were desirous of placing the new garden by the Duke's Walk, in the neighbourhood of Holyrood, but this did not seem suitable for many reasons to the botanical experts. Graham opposed the site strongly and exerted himself strenuously to secure another which was ultimately chosen in Inverleith Row, where a large area of something over 14 acres was available. Graham was successful in his efforts, and the garden was finally established there. The task of laying it out and developing it occupied him for several years, a work in which he had the assistance of the curator McNab, grandfather of Professor McNab, who held a Chair at Dublin many years later.

In the ordinary duties of a university professor Graham was very successful. He was an able lecturer, "no dulness or tedium in him, but as fresh and healthy and full of life as the youths around him." He introduced the practice of giving a winter course of lectures as well as a summer one, and in connection with the latter he organised Saturday botanical excursions throughout the term. In the course of time he and his pupils in this way explored large districts of Scotland, and accumulated considerable

material towards a *Flora* of Scotland which he contemplated, but was never able to finish. When he first went to Edinburgh he lectured on the lines of the Linnean system, but finding this being replaced by the natural system as the influence of De Jussieu and his school made itself felt, he gradually adopted the new ideas.

In 1836 several of his old pupils, headed by Hutton Balfour, who became his successor, founded the Botanical Society of Edinburgh, and Graham was made the first President.

During the last two years of his life Graham had as assistant J. D. Hooker, afterwards joint author of the *Genera Plantarum*.

Graham died in 1845, and was succeeded by Dr. Hutton Balfour.

In the north of Scotland little of importance took place during these years. Knight continued to conduct the study at Marischal College, Aberdeen ; the University of King's College joined that at Marischal College to carry on a joint medical school, whose lecturers received the official sanction of both institutions, and Knight held the office of Lecturer in Botany in connection with it from 1827 till 1839.

In 1836 Alexander Murray began the publication of a book on the botany of the north and east of Scotland, which promised to be of some importance, but the premature death of the author prevented its completion. It was entitled, " The Northern Flora, a Description of the Wild Plants belonging to the North and East of Scotland, with an account of their places of growth and properties."

A more local work of less ambitious character was brought out in 1838 by George Dickie, afterwards Lecturer in Botany in King's College, under the title, *Flora Aberdonensis*. It gave a list of the plants growing wild within a radius of fifteen miles from Aberdeen.

Another botanist of some note was William Gardiner, who published in 1849 a *Flora of Forfarshire*. He was always in humble circumstances, but with an ardent love for botany he devoted all his leisure to exploration of the plants of his neighbourhood, and made a great reputation among the naturalists of the time.

Litton

We have seen that the early part of the nineteenth century saw the foundation of both the botanic gardens in Dublin. Under the management of Wade and Underwood, Glasnevin was eminently successful, nor did the death of Wade in 1825 militate against their progress. He was succeeded in the chair of botany by Dr. S. Litton.

In 1830 the Botanical Committee instituted some very extensive alterations and improvements. The cattle and hay gardens were abolished, thus leaving more ground available for scientific purposes ; the arboretum was enlarged, and more space devoted to the arrangement of plants in their natural orders. It was decided also to take down the worst houses, and to erect a new and more substantial range in their stead.

Underwood was succeeded in 1834 as superintendent of the gardens by Ninian Neven, who carried out great alterations in its arrangements during the four years of his tenure of the post. The hothouses were repaired and stocked with new introductions, a different class of assistants was introduced, and a general system of professional instruction instituted.

Neven was succeeded in 1838 by David Moore, who came to Ireland from Dundee in 1828. On his first arrival he was made assistant to Mackay at the Balls Bridge Garden, and remained there till ten years later he was put in charge of Glasnevin. Moore published several papers in the local journals and in the *Phytologist*. As a botanist he was more particularly attached to the study of the Bryophyta, and in 1873 he published a *Synopsis of Mosses*. Perhaps his best work was his share in the *Cybele Hibernica*, which he published in 1866 in collaboration with Mr. A. G. More. It was based upon a thirty years' study and investigation of the geographical distribution of plants in Ireland.

The course of improvement of the gardens at Glasnevin entered upon by Neven was continued by his successor, and many extensive alterations were carried out. All the old houses, except the octagon, were removed, and a splendid range of curvilinear wrought-iron conservatories were built in 1843, partly at the cost of the Royal Dublin Society and partly at that of the government, who voted £4000 for the purpose.

In 1840 a Mr. John Robertson bequeathed to the Society a botanical library " for the use of the Professor of Botany, the

Curator of the Garden, and the pupils thereof." This appears to have been the nucleus of the Botanic Garden Library at present existing.

In his annual report for the year 1839 Mr. Moore called attention to the commencement of a herbarium in connection with Glasnevin, he having dried 500 specimens for it during that year.

Professor Litton died in 1846.

Coulter

The garden at Ball's Bridge was increased in 1832 by the addition of 2 acres along the Blackrock Road, and the present entrance gates and a strong iron railing were put up. They continued under the management of Professor Allman and Dr. Mackay through the whole of our present period. The Professor published his best-known work in 1828 under the title, "Analysis per differentiis constantes viginti inchoata, generum plantarum quæ in Britanniis, Galia, Helvetia sponte sua crescunt." Like his two predecessors he resigned his chair, his death taking place between two and three years later, in 1846.

The herbarium, which seems to have received some attention after Browne's donations, was considerably enriched during the latter part of this period, through the services of Dr. Thomas Coulter. During Mackay's administration so far, a collection of East Indian plants had been presented by Dr. Wallich, and Mackay had added his own herbarium, which contained specimens from South Africa and the Brazils.

Coulter was an Irishman by birth, and had been educated at Trinity College, where he graduated in 1817. He was an ardent botanist and explorer, and accumulated very large collections of plants from the continents of Europe and North America. Soon after his graduation he studied at Paris and at Geneva, where he made the acquaintance of the De Candolles, with whom he maintained a correspondence. He published a *Mémoire sur les Dipsaceæ* at Geneva in 1823.

Between the years 1824 and 1833 he was engaged on a botanical exploration of Central Mexico and California. On his return he went back to his old Alma Mater, was given rooms in college, and was appointed Keeper of the Herbarium. He probably at that time presented his large collections to the college. They contained large numbers of the North American plants, together with a very extensive series of European species, among them being the

types of the plants of his monograph of the Dipsaceæ. In addition to this handsome donation of specimens Coulter prepared a long manuscript catalogue of the orders, genera, and species then arranged according to the suggestions of De Candolle, and based on his great *Prodromus*. Unfortunately the enormous amount of work falling to him prevented his arranging the series of Mexican plants, a task which fell to the charge of his successor, the great Harvey.

Coulter held his position at the herbarium till his death in 1843.

BOOK VI

FROM LINDLEY TO DARWIN

BOOK VI

CHAPTER XLI

KEW GARDENS UNDER SIR W. J. HOOKER

The appointment of Sir W. J. Hooker to be Director of Kew, now nationalised and put under a Government Department, resulted in a sweeping and much-needed reform. From 1841, the year of his appointment, until 1859, when he presented to Parliament an elaborate survey of the changes and improvements made there under his direction, his aim was to make of the Royal Gardens "a complete national establishment." He had to remember that the Government in taking them over aimed at two distinct things: in the first place, the healthful recreation of the public, "gratifying the national love of gardening, and affording much popular information as to the appearance, names, uses, and native countries, etc., of an extensive series of useful and ornamental plants from all lands and climates, together with their products, whether as food, drugs, dyes, timbers, textiles, or cabinet work," and secondly, the encouragement of horticultural and scientific botany, "promoting the useful arts which depend on vegetable produce, supplying information to botanists, aiding their publications, and imparting a knowledge of plants to travellers, merchants, and manufacturers, also by training plant collectors and gardeners for home, colonial, and foreign service." In fact, what was aimed at was a centre for the coordination of all the botanical enterprise of the nation.

The first step in the new direction was a recommendation made by Hooker that the gardens should be thrown open to the public every week-day afternoon. Their appreciation of this boon was shown by the number of persons availing themselves of it, who amounted to nearly 10,000 during the rest of the year. How great a privilege this freedom of entry subsequently came to be regarded is shown by the fact that more than a million visitors entered the gardens in the year 1883.

The Botanic Garden as it was transferred consisted of only about 11 acres of ground; it contained only ten plant-houses of any considerable size, of which only two, the Orangery and the great Conservatory near the entrance gates, were standing at the end of the century.

The Orangery had been erected in 1761, and was at the time of which we are writing used as a Conservatory for the taller trees. It was later converted into a Museum. The Conservatory near the entrance, used in 1841 for similar purposes, was given up to the culture of tropical plants in 1863.

The long-talked-of extensions to the gardens were not long delayed. In 1842 the Queen consented to the addition of a few acres of the Pleasure Ground to the old Arboretum, so that a new entrance could be provided to the gardens from Kew Green. In 1843, 48 acres were added, on which a new Pinetum was constructed on a site set apart for the erection of a larger Palm House.

From 1840, the date of his retirement from the management of the garden, Aiton had under his care the charge of a portion of the Pleasure Grounds adjacent to them. In 1845, however, he relinquished this, and these grounds together with the Deer Park were added to the gardens, increasing them by no less than 528 acres. They then extended from Kew Green to the Thames at Richmond, a distance of some two miles. A new Arboretum was at once constructed upon the old Pleasure Grounds, the Deer Park being held in reserve. The Royal Kitchen Gardens, about 15 acres in extent, were annexed to the Botanic Garden in 1846. The Director was relieved of the charge of the Deer Park, however, in 1850, when the charge of the gardens was put under the newly-constituted Board of Works.

The Arboretum consisted in all of about 250 acres, separated from the Botanic Gardens by a wire fence, which was furnished with four gates. The old Arboretum consisted only of about 5 acres, planted by Aiton; it was situated in the northern part of the gardens, and was described by Hooker in 1847 as "a small piece of ground . . . but crowded with hardy trees and shrubs of extreme interest and value." Near the Temple of the Sun were noble trees of the Turkey oak, the oriental plane, a good cedar of Lebanon, a very large locust tree, a lotus of North America, a fragrant sassafras, and a healthy though young cork-tree. Along the wall by the east end of the Orangery were American limes, oaks, hickories, red- and yellow-flowered horse-

chestnuts. In the other direction were many other interesting trees—Napoleon's willow, the paper birch, many rare pines, the manna ash, and the Glastonbury thorn. Hooker aimed at obtaining in the Pleasure Grounds an Arboretum that should contain every tree and shrub capable of withstanding the open air in this climate. A lake was formed there under his directions, and the Queen's garden, a beautiful piece of ground reserved for the use of Her Majesty, and situated at the south-western corner of the Pleasure Grounds, was enlarged by 14 acres of the Royal Deer Park.

Nor was it long before new structural additions were in progress. In 1844 it became necessary to find further accommodation for orchids, which, through purchases, exchanges, and presentations, had greatly increased in number. A lean-to house 60 feet long and 17 feet wide was doubled so as to make a span-roofed house 14 feet wide. The centre was filled with a staging of slate shelves facing north and south, with a passage in the centre, and passages and stone shelves on both sides and ends. The roof was glazed with thick sheet-glass in squares 4 feet in length. The house was thus well fitted and heated, but the large area, dry stone paths, smooth slate shelves, and large squares of thick sheet-glass were ill-adapted to keep tropical orchids in a healthy condition. They did not thrive, and in 1846 a new Orchid House was built, in which in addition to the Kew collection the Woburn orchids presented by the Duke of Bedford were stored, as well as another collection made by Mr. Clowes of Manchester, which was rich in South American species.

In 1844 also another enterprise was undertaken—the construction of a new Palm House. This was partly planned by the Director, and when completed in 1848 was 362 feet long, 100 feet wide, and 66½ feet high for the greater part of its length. Its glass covering measured about 45,000 square feet. For several years the palms stood on the floor of the house, but in 1854 a part of the perforated iron floor was removed, and three beds, each 8 feet wide, were made on each side of the centre passage of the house, with passages 4 feet wide between them. The large palms were planted in the centre area of the Palm House, and the others grown in round and square plant boxes and pots of various sizes, the smaller ones being placed on side shelves. In his *Guide to Kew Gardens*, published in 1853, Sir W. J. Hooker directed especial attention to the date, coco-nut, oil-nut, and cabbage palms, the ivory-nut and sago palms, the chocolate-nut, tamarind, mango,

bread-fruit, and cinnamon. In his report for 1854 he says: "The palm house stove was never more beautiful than at the present moment, and so rapid has been the growth of some of the trees and shrubs that we have been obliged to move them from their high tubs and sink them in the ground." In 1856 a journalist wrote of this house and its contents: "On entering the magnificent building the visitor suddenly finds himself in the midst of a tropical vegetation. Broad-leaved plantains, bananas, strelitzias, and uranias, feathery bamboos, tree ferns, and tamarind trees, spiny screw-pines and cacti are mingled with numerous palms of all dimensions and sizes, the whole being gracefully interwoven and surrounded by creeping and winding plants, passion flowers, bauhinias, jasmines, aristolochias, and others, and agreeably relieved by the vivid green of densely crowded lycopodiums, covering the ground between them."

A new Fern House was constructed from two others already existing in 1846, and the Water-lily House, standing close to the Palm House, was built in 1850. It was designed chiefly for the purpose of cultivating *Victoria regia*.

In 1850 the Gardens and Pleasure Grounds were put under the control of the Board of Works and Public Buildings, the old Board of Woods and Forests being abolished.

The next great extension of the houses dates from 1854-55. When Sir W. J. Hooker took the Directorship, the collection of succulents, "made chiefly by Masson and Bowie," was housed in a low lean-to stove, 40 feet long, fitted up with shelf staging in two directions, one for euphorbias and cacti, the other for mesembryanthemums, crassulas, sempervivums, small species of *Aloe*, gasterias, etc. The collection increased by gifts and purchases, especially in cacti, agaves, and other allied species and plants from Mexico. In 1854 the erection of a new house for its accommodation was commenced; it was 200 feet long and 30 feet wide, having a span roof facing east and west 15 feet high. Climbers were placed in a shallow trough, 2 feet wide, filled with soil and supported by brick arches, and, flowering freely, were then trained up the rafters. This trough occupied the sides and ends of the house, the floor of which was covered with sand or gravel. The pots containing the low-growing plants were arranged on the floor according to their families, while in the centre the taller plants, also in pots, were placed. Of this house Sir W. J. Hooker said in his Parliamentary Report for 1855: "The erection during the year of a new house for succulent plants, 200 feet long,

30 feet wide, and 15 feet high, has enabled us to display—and to advantage for the first time—our noble collection of medicinal aloes and euphorbias, grotesque cacti, and fibre-bearing agaves; this is perfectly unique of its kind."

Among this collection was a cactus which Sir J. D. Hooker describes as the wonder of Kew; it was globular in shape, measured 9½ feet in girth, and weighed a ton. Sir W. J. Hooker paid fifty guineas for "its transport from the mountains to the coast of Mexico in a wagon drawn by six oxen. Owing to a bruise received in transit it very slowly rotted away."

The authorities of Kew, including the Director and the Commissioners of Woods and Forests, were anxious to make the institution as useful in the development of medical education as Chelsea had been, and to that end proposals were made to annex the Chelsea Garden, or to found an independent medical garden at Kew. Much thought and attention were devoted to the schemes in 1843-45, but nothing came of either of them.

Though the education of students was thus not the first or the main care at Kew it was not altogether overlooked. In 1847 the herbaceous and grass collections were transferred to new quarters on the addition of the Royal Kitchen Gardens, as already mentioned. Three acres of ground were thus set at liberty and were laid out in beds of various sizes to illustrate the different genera of the system of De Jussieu. In 1853 the foreman, James Niven, drew up a catalogue of these plants, a considerable number of copies of which were printed for distribution at the expense of the gardens, in order to help in making exchanges. This catalogue consisted of sixty-two pages, and enumerated 5414 species arranged under their natural orders. In addition to these two collections much appreciated by students, were a separate one of British plants which the Director commenced to get together in 1843 and another of hardy medicinal plants contiguous to the others, made on the acquisition of the ground called the Paddock in 1853.

By a very curious chain of events the administration of Sir Joseph Banks was connected with that of Sir W. J. Hooker in the circumstances attending the foundation of the Kew herbarium and library. It will be remembered that Banks put forward proposals for such an establishment, and King George III. purchased a house in the immediate vicinity of the grounds, then the property of a Mr. Hunter, to house the collection. But little progress was made, however, only a few bookshelves being put up, when the plan was abandoned. In 1853 Sir W. J. Hooker took up his resi-

dence in a house at Kew, situated, indeed, within the limits of the gardens, and it became necessary to find accommodation for his herbarium, which by this time had attained to very great dimensions. Just at this juncture the house which Banks had originally contemplated as suitable for the accommodation of a herbarium and library was available for the purpose, and the Director's plants and books were transferred to it. The Commissioners further agreed that a competent curator should be appointed to take charge of them, on condition that they should be made accessible to botanists. In this same year a herbarium and library which had been collected by Dr. Bromfield were presented to Kew by his sister after his death. This proved to be really the nucleus of the present herbarium, for the collections of Sir W. J. Hooker were not purchased by the Government till 1866. Housed together, however, the basis of the Kew herbarium was constituted by them, and they were added to continuously during the lifetime of the Director. The chief acquisitions were: (1) The library and herbarium of Bentham, presented by him in 1854. It contained his Pyrenean plants, together with those of his subsequent explorations—a collection second only to Hooker's own. (2) The collections of Indian and Thibetan plants made by Thompson and J. D. Hooker. (3) Several minor collections of Asiatic plants that had been accumulating at the India House for many years. (4) The herbarium of Borrer, chiefly British. (5) The Australian plants collected by Allan and Richard Cunningham in New South Wales and Queensland in 1835-38. (6) Mrs. Griffiths' collection of British Algæ. (7) Dr. Boot's specimens and drawings illustrating the genus *Carex*. (8) Dr. Lindley's orchid herbarium. (9) Burchell's South African and Brazilian plants, comprising about 15,000 species.

The Museums of Economic Botany had a small beginning in 1847, when Hooker devoted to the purpose "a very humble building which had been used for the conservation of the fruit for the Royal table." To it he transferred various vegetable products in demand economically, which he had been accumulating for forty years in connection with his own herbarium. This nucleus of a museum of structural and economic botany he placed under the charge of Alexander Smith, son of the Curator of the gardens. In 1856 the present Museum No. 2 was built, the public being admitted to it in the course of the next year. In 1863 Museum No. 3 was opened as a timber museum, the basis of the collection being the large series of colonial timbers obtained from the London

International Exhibition of 1862. It occupies the building formerly known as the Orangery at the northern extremity of the Broad Walk leading to the ornamental water and palm stove. It is 142 feet long, 30 feet wide, and 25 feet high.

The first curator, Mr. Alexander Smith, was obliged to retire in 1858, his health failing; his successor, Mr. Jackson, held the position upwards of forty years, retiring almost at the end of the century.

During these years the Arboretum was the scene of many changes and improvements. Chief among these was the construction of the great Temperate House, originally called the Winter Garden. This was an object of intense desire to the Director for many years prior to its erection in 1860 and the following years. In his report for 1857 he said: "All the plant-houses are progressing favourably, with one exception, to which I have already alluded as a source of deep concern. Unless we have, at once, a structure suited to the reception of our large trees and shrubs which will not bear frost, especially that once-celebrated collection of pines, Araucarias, Proteas, etc., that will soon be past recovery. . . . The gardens cannot be deemed complete till the trees and shrubs of temperate climates are as well cared for as the tropical plants, for whose reception our noble Palm House was erected thirteen years ago. . . . The Conservatory in question would certainly cost a large sum of money, but not *nearly* as much as did the Palm House, which involved several items not requisite in a structure for hardier trees and plants." In answer to this appeal plans were prepared in 1859 and the building commenced in the next year, but only part of it was erected at the time, the two wings not being completed till nearly the end of the century.

The plan which greatly enriched the Kew collections, and which was originally inaugurated by Sir Joseph Banks, viz., of sending collectors of plants and seeds into little-known countries, was restored with much success by Hooker, and several important botanical missions and explorations were undertaken during his directorship, financed partly by the gardens, partly by other departments of Government.

M. Bourgeau, appointed to Captain Palliser's expedition for exploring the unknown territories of British North America, especially on the east side of the Rocky Mountains, despatched very valuable collections to Kew. He was sent out under the auspices of the Secretary of State for the Colonies.

Dr. Kirk, botanist in Dr. Livingstone's expedition to the Zam-

besi, and for making research into the interior of tropical East Africa, was sent out by the Lords of the Admiralty. Another important mission was that of Mr. Milne, botanist and collector in H.M.S. *Herald* for survey of the Fiji and other scarcely known islands in the South Pacific Ocean. This, too, was an Admiralty expedition, only a small portion of his salary falling on the garden.

The Secretary of State for the Colonies appointed Dr. Lyall as botanist to the very important expedition sent out to determine the boundary line between the British and United States' possessions in British Columbia.

Mr. C. Wilford, at one time an assistant in the Kew herbarium, sent to Kew collections from Hong Kong and Formosa. He then joined H.M.S. *Actæon*, a surveying vessel about to proceed to the coast of Eastern Tartary, a special grant being given by the Treasury to Kew for his use, while the Admiralty granted him a free passage.

Two very important West African voyages were Dr. Blaikie's expeditions up the Niger. Mr. Barter, the botanist attached to the party, sent home to Kew large collections of great interest. Important collections were received also from South America through Mr. Spruce's exploration of that continent, by way of the Amazon and the Andes, crossing from the Atlantic to the Pacific. Spruce had visited the Pyrenees in 1845, and had studied chiefly the Bryophyta of that region. He sent dried specimens of more than 7000 species to Kew from South America between 1849 and 1864. He became the great authority on the South American Hepaticæ.

Dr. Harvey, Professor of Botany in Trinity College, Dublin, himself a very intimate friend of the Director, sent an interesting collection formed in Australia, the South Sea Islands, and Chili. The noted Australian botanist and explorer, Ferdinand Müller, sent valuable plants obtained in an expedition across the northern part of that continent. Very interesting collections from Java and other Dutch East Indian possessions were sent to Kew by Dr. de Vriese. Others were supplied by the colonial botanic gardens at Calcutta and in Ceylon. The great exhibitions were also contributors to the riches of Kew, particularly those of London in 1851 and Paris in 1855. Besides gifts, valuable exchanges were effected with the Imperial Gardens at Paris and St. Petersburg, the Royal Gardens of Berlin and Hanover, the Belgian nurseries, the Royal Horticultural Society, and the leading English nurseries.

But Hooker did more than enrich Kew by these means. He made it minister to the service of the Empire by sending out to the different colonies such plants of economic importance as would be likely to flourish there, so laying the foundation for a measure of agricultural development and material prosperity. This made Kew in a measure a nursery for the economic products of the Empire. The scheme dates back to 1860 and 1862, when by its means the Peruvian barks were introduced into India and our tropical colonies. The plants were brought from Peru by Mr. (afterwards Sir Clements) Markham, were nursed for a while at Kew, and then sent out to India and established in the Nilgiri Hills.

So important a measure as this was not likely at first to yield uniformly good results. It is not surprising to find that a similar attempt to introduce from Brazil the Ipecacuanha plant was not successful. It was only an institution like Kew that could even make the attempt.

A greater success was attained with the importation of plants into the Island of Ascension. The first attempt was made in 1843, and Kew supplied seeds as well as cases of living plants for many years in succession. Gradually the scheme succeeded; whereas at the outset there was only one tree on the island and no shrubs, in 1865 the island possessed thickets of various kinds of trees, many shrubs and fruit trees. It was transformed from a useless desert into a fertile island, Captain Barnard reporting to the Admiralty: "Through the spread of vegetation the water supply is excellent, and the garrison and the ships visiting the island are supplied with abundance of vegetables of various kinds."

It will be seen from what has been said how much the nation owes to Hooker's work at Kew. We have not so far touched upon its strenuous character, nor what it cost him. The general superintendence of the whole establishment from the first devolved upon him, as well as the initiation of all these schemes for development. He describes himself in his general report as "responsible for the good keep and efficient working of every part." He conducted all the correspondence, which was very large, with the colonies and other foreign possessions. Every day he visited the gardens and houses, directing the exchange of growing plants and seeds, prepared the reports, revised the estimates, and recommended all alterations and improvements. Once a week he inspected and signed the bill vouchers and accounts of the garden, museum, and library. He selected foremen and gardeners for colonial establishments, and supplied the names of plants and

their products to manufacturers, merchants, druggists, nurserymen, and travellers in all parts of the world.

The strain of these labours had grown so great by 1855 that the Director's son, Dr. (afterwards Sir) J. D. Hooker, was appointed Assistant Director.

The Curator, Mr. John Smith, whose official connection with the gardens lasted from 1822-64, took the practical superintendence of the botanic garden, stoves and greenhouses, the ticketing of the plants, the supervision of the plants and seeds received and sent away, and the arrangements connected with the hire and discharge of the foremen and gardeners, being assisted in these duties by a Sub-curator. He published two popular books on ferns, a *Handbook of Domestic Botany*, and a *Dictionary of Popular Economic Botany*.

For the use of the foremen and gardeners there was established a gardeners' library and reading-room, open every evening. It was supplied with a selection of the more useful works on horticulture, elementary botany, landscape gardening, agricultural chemistry, etc., together with a few volumes of voyages and travels, two weekly horticultural journals, some maps, and a supply of stationery for the use of readers.

Great as was the charge of this vast establishment resting on the shoulders of the Director, he by no means relinquished his literary work. Of the writings which were published by him at Kew were: twenty-three volumes of the *Botanical Magazine*, containing 1440 plates; the *Icones Plantarum*, with 700 plates; the *Journal of Botany*, and *Kew Gardens Miscellany*, nine volumes; with other periodicals. Special mention must be made of his extensive work on ferns, to which he had all his life been attached. It would be difficult to over-estimate the importance of his labours in this group. They began soon after his settlement at Glasgow, where, in collaboration with Greville, he published the *Icones Filicum* in two volumes with 260 coloured plates. He commenced at the same time, with Greville's help, an enumeration of all known ferns and Lycopodiaceæ, which appeared in the *Botanical Miscellany*. In 1838 he began, with Francis Bauer, the *Genera Filicum*, a work unique in point of artistic representation of fern analyses. About half the plates were by Fitch. From 1846-64 the culmination of his fern work appeared in the *Species Filicum* in five volumes, illustrated by Fitch and other artists. A melancholy interest attaches to the *Synopsis Filicum*, published posthumously in 1868. He was working at it till within a few days of his death, and after

his fatal seizure part of the proofs and some of the manuscripts were found on his desk. Dr. J. D. Hooker put the material into the hands of J. G. Baker, who completed it and published it in one 8vo volume in 1868. Hooker made other important contributions to the literature of the group, illustrated by between six and seven hundred plates. Sir Joseph Hooker, in a sketch of his father's life, which appeared in 1902, estimated that he published in all, at Glasgow and Kew, upwards of 1200 plates of ferns and descriptions of 2500 species.

It was wonderful that a life conducted under such strain should have been so prolonged. His general health was good, and he bore his labours lightly. He died in 1865 in his eighty-first year.

Among those who played a subordinate part at Kew and who were of great assistance to Sir William Hooker in his literary work, was William Fitch, the distinguished botanical artist who may be regarded as the successor of Francis Bauer, as Bauer had been of Ehret. What Bauer was to Robert Brown, Fitch was to Hooker. Born in Scotland in 1816 of humble parentage, he entered Hooker's service at Glasgow, and began his artistic career by illustrating the *Botanical Magazine* and the *Icones Plantarum*. He followed his patron to Kew and supplemented the work of Francis Bauer on the *Genera Filicum*.

Fitch had a wonderful faculty for catching and depicting the salient characters of a species, sketching very rapidly its peculiar features, so that his drawings were comparable with the artistic work of Bauer in their life-like presentation of a plant. He lived to a great age, passing away at Kew in 1892.

It is a task of great difficulty to present any adequate representation of the obligation under which Sir W. J. Hooker placed the botanists of his age, and indeed of succeeding years. His work may well be said to mark a revolution in the science. An appreciation of his labours was published in the year after his death from the pen of Professor Asa Gray, which the present author trusts he may be pardoned for reproducing from the memoir already referred to, written by his son Sir J. D. Hooker: "Our survey of what Sir William Hooker did for science would be incomplete, indeed, if it were confined to his published works—numerous and important as they are—and the wise and efficient administration through which, in a space of twenty-four years, a Queen's flower and kitchen garden and pleasure grounds have been transformed into an imperial botanical establishment of unrivalled interest and value. Account should be taken of the

spirit in which he worked, of the researches and explorations he promoted, of the aid and encouragement he extended to his fellow labourers, especially to young and rising botanists, and of the means and appliances he gathered for their use no less than for his own. The single-mindedness with which he gave himself to his scientific work, and the conscientiousness with which he lived for science while he lived by it, were above all praise. Eminently fitted to shine in society, remarkably good-looking, and of the most pleasing address, frank, cordial, and withal of a very genial disposition, he never dissipated his time and energies in the round of fashionable life, but ever avoided the social prominence and worldly distinctions which some sedulously seek. . . . Nor was there in him, while standing in a position like that occupied by Banks and Smith in his early days, the least manifestation of a tendency to overshadow the science with his own importance or of indifference to its general advancement. Far from monopolising even the choicest botanical materials which large expenditure of time and toil brought into his hands, he delighted in setting other botanists to work on whatever portion they wished to elaborate; not only imparting freely, even to young and untried men of promise, the multitude of specimens he could distribute, and giving to all comers full access to his whole herbarium, but sending portions of it to distant investigators, as long as this could be done without too great detriment or inconvenience. He not only watched for opportunities for attaching botanists to government expeditions and voyages, and secured the publication of their results, but also largely assisted many private collectors, whose fullest sets are among the treasures of far the richest herbarium ever accumulated in one man's lifetime, if not the amplest anywhere in existence."

CHAPTER XLII

THE ROYAL HORTICULTURAL SOCIETY AND OTHER LONDON INSTITUTIONS

THE establishment of Kew and its development on such a scale by Hooker naturally was not without effect on its humble rival at Chiswick. Though Lindley struggled hard in the interests of the Royal Horticultural Society, the days of adversity were not far off, and its decadence was inevitable. For a considerable time, however, there was no departure from the course which had been followed from the time the garden was established. In 1837 Mr. Hartweg was sent out to America by the Society to collect in Mexico, Guatemala, and Peru. Subsequently he visited California on a similar errand. He sent home to the garden a large number of new plants, among them several new conifers, all the *Achimenes*, and many new orchids. In 1842 the Society undertook another important enterprise, sending out Robert Fortune to China with a large number of plants and seeds of European fruits, vegetables, and flowers for distribution amongst the Chinese. These importations have proved of considerable benefit to the people of Northern China. Born at Kelloe in Berwickshire in 1813, Fortune entered the Botanical Gardens at Edinburgh, and subsequently became superintendent of the indoor plant department at Chiswick. The expedition to which we are now alluding, and which occupied him from 1843-45, was of great value to horticulture, resulting as it did in the introduction to England of the tree pæony, the "Chusan Daisy" (the parent of our garden chrysanthemums), the Japanese anemone, *Weigelia rosea*, *Dielytra*, and *Citrus japonica*. While engaged in botanical work in China, Fortune made observations on the growth and cultivation of the tea-plant, and subsequently went to India with a view to its introduction into that country. A few years after his engagement to collect for the Horticultural Society had terminated, the East India Company arranged with him, in 1848, to make some experiments with the tea-plant in the North-west Provinces of India. These experiments were successful and laid the foundation of the cultivation of tea in India and in Ceylon. Fortune subsequently paid

several visits to Japan, introducing to England from that country *Kerria japonica*, *Aucuba japonica*, *Lilium auratum*, and the golden larch. He published, in 1847, "Three years' wanderings in the Northern provinces in China, with an account of the Agriculture and Horticulture of the Chinese"; besides several works dealing with the culture of the tea plantations.

Among the efforts made by the Society to add to its usefulness at home may be mentioned the establishment in 1826 of a course of instruction for young gardeners, and the inauguration of the Chiswick flower show in 1833.

But the numerous foreign expeditions which it sent out, the expenses involved in the cultivation of the new plants thus introduced, and its magnificent though costly publications caused the Society to exceed its annual income. The years 1850-60 were especially a time of great financial difficulty, and at one time it was thought that the work of the Society would have to be abandoned. In 1858, however, the Prince Consort became its President, and resolved to secure to the country the benefits that were in danger of being lost. In 1859 he proposed that the Commissioners of the Great Exhibition of 1851 should be invited to co-operate with the Society, and a new departure should be made on the South Kensington estate which was under their control. This was successfully carried out, and in 1861 the magnificent South Kensington conservatory and gardens were opened by Queen Victoria. Brilliant as the scheme promised to be at first, it proved rather a retrograde step. The cost of making and keeping up the gardens was so great that it entailed on the Society a debt of nearly a hundred thousand pounds. To the great grief of the nation the Prince Consort died towards the end of the same year. Deprived of his active influence, the Commissioners inaugurated a series of exhibitions, which flooded the gardens with such crowds of pleasure-seekers, that the original purpose of the Society began to be lost sight of, and the Society itself ceased to be a factor in matters truly scientific or botanical. From this period onwards till very late in the century, general decadence marked its career.

The Royal Botanic Society and Regent's Park

In the year 1839, while the gardens at Chiswick were still flourishing, it was felt by many horticulturists that a botanic garden nearer to the centre of London was for many reasons desirable,

and the Royal Botanic Society of London was formed under distinguished patronage. It obtained a Royal Charter "for the promotion of botany in all its branches, and its application to medicine, arts, and manufactures, and also for the formation of extensive botanical and ornamental gardens within the immediate vicinity of the metropolis." The Charter was granted to the Duke of Norfolk, the Duke of Richmond (who became the first President of the Society), the Earl of Albermarle, Lieut.-Col. Rushbrooke, Philip Barnes, and James de Carle Sowerby, the first secretary.

At this time the Inner Circle of Regent's Park was a nursery garden, known from the name of its proprietor, as Jenkyn's Nursery. In area about 18 acres, this ground consisted of a nearly level plateau but rising gently from the circumference to the centre. While the centre point is 129 feet above mean sea-level, the road at York Gate is 96 feet. The Society took over this site, its circumference being clearly marked out by a belt of elms. A lawn with a group of trees at the extreme west, an inner circle of small birch trees, four or five old elms near the reservoir of water, a general nursery stock planted about the remainder of the ground, two old greenhouses, a wooden and brick cottage, and a few sheds, formed the unpromising unpicturesque foundation of the present botanic gardens, now among the most beautiful features of suburban London.

The Society on becoming possessed of these nurseries offered a prize for the best plan of transforming them into a garden, which should be at once picturesque and suitable for scientific purposes. Hints were taken from the prize design, but on the recommendation of Loudon, Marnock, the Curator of a botanic garden at Sheffield, was invited to become the Society's Curator, and to lay out the ground. He did so accordingly and with such skill that it is difficult to realise that the contour, undulations, and general design of the landscape are all artificial. After clearing the ground he formed the lake and mound, and thoroughly drained the very heavy yellow clay which composes the greater part of the garden. The terrace on the north side on which the main conservatory stands was then formed. The conservatory was the first iron house of any considerable size erected in England; it was designed and built by Turner of Dublin in 1845. The whole of the heating apparatus is underground, so that the entire area of the conservatory is unimpeded by hot-water pipes.

Behind the conservatory was constructed the exhibition ground,

with winding walks and grass banks for grouping the plants, instead of showing them in long narrow tents with green baize staging.

While the general planting of the ground was that of an English landscape garden, other groupings of trees and shrubs were made to constitute an Arboretum. On the west was a spring garden, well protected from cold winds by a band of shrubs. On the north-west were an American garden, an Italian flower-garden, a Rosary, and an agricultural department. The two latter were ultimately abandoned; it was found very difficult to get roses to flourish in a comparatively confined and soot-laden atmosphere, while the continual increase in the numbers of medicinal and economic plants rendered it impossible to afford the space that was required for agriculture.

On the east the herbaceous plants were cultivated in a special enclosure, and were arranged according to the Natural System. The plan usually adopted in botanic gardens of making the beds rectangular and uniform was not followed, but a more artistic design was employed, the beds being of different shapes and sizes, allowing the Natural Orders to be grouped together more on the lines of their mutual relationships.

Between the conservatory and the herbaceous ground a department was constructed, devoted to medicinal and economic plants. It was furnished with a greenhouse divided into three sections, each of which could be maintained at a particular temperature, while the special plants to which the space was allotted were arranged in beds near by.

Besides the large conservatory there were constructed a warm-water tank for *Victoria regia* and other flowering aquatics, an orchid house, warm and cool fern houses, alpine frames, and the usual ranges of stoves, propagating houses. and so forth, while in a separate part of the garden a museum was constructed.

During her lifetime Queen Victoria continued to be the patron of the Royal Botanic Society of London. The first President was the Duke of Richmond, who was succeeded in 1842 by the Duke of Norfolk. The Prince Consort took the Presidency in 1856, and held it to the time of his death in 1861.

The exhibitions or flower shows of the Society were inaugurated in 1843, and maintained their popularity to the end of the century. Frequently more than 20,000 visitors have been present.

It is unfortunate that financial exigencies have made it necessary that this side of the Society's operations should tend to encroach

upon the scientific purposes for which the gardens were projected. The latter have not been altogether neglected, courses of lectures on botanical subjects having been always a feature of the work.

Chelsea Physic Garden—Fortune

Matters at Chelsea at about this time took a turn for the worse, and its palmy days were seen to have departed. The friction between Lindley and Anderson, it is true, had been ended by the submission of the latter, but for some years little was done but ordinary routine work. In 1846 Anderson died, and for a short time there seemed a prospect of something like a return of the old activities. Lindley recommended as the new Curator, Robert Fortune, who had just returned from his expedition to China undertaken for the Royal Horticultural Society, and he remained at Chelsea till the East Indian Company engaged him to undertake the investigations as to the cultivation of the tea-plant in India, to which reference has already been made. His stay at Chelsea was limited to two years, for though he wished to retain his curatorship and to give only a definite term to the Indian problem, the committee thought it best that he should resign the post. His tenure of the Chelsea office was marked by much energy; he re-arranged the plants in the garden, and was instrumental in obtaining a considerable extension of the area under glass.

Thomas Moore

Fortune was succeeded by Thomas Moore, a young man of twenty-four years of age, who had had a careful horticultural training and who had assisted Marnock in laying out the gardens of the Royal Botanical Society at Regent's Park. He was appointed Curator to Chelsea mainly through the influence of Lindley.

Moore, in the early years of his Chelsea life, took up a good deal of editorial work, some of which continued to occupy his attention for many years. He was editor of the *Gardeners' Chronicle* in 1850 and 1851, and again from 1866 to 1882. As a botanist he was specially attached to the study of ferns, on which he published several works. His first, a *Handbook of British Ferns*, appeared in 1848, his *Popular History of British Ferns* in 1855, and several other books later. He commenced an *Index Filicum* in 1857, and continued to issue it till 1863, but he never completed it. One of his greatest services to the literature of the science was the

Treasury of Botany, which he edited in conjunction with Lindley in 1865. In the compilation of this valuable compendium he had the collaboration of most of the leading botanists of the time. It still holds its own as a very valuable work of reference.

The year 1853 was the darkest in the history of the Chelsea garden. Financial pressure became very heavy, and the Apothecaries' Society was compelled to face the question of relinquishing its management, allowing it to revert in these circumstances to the Earl of Cadogan, the representative of the descendants of Sir Hans Sloane. Negotiations were set on foot in 1853, and while they were proceeding the Society determined to cut down its expenditure on the garden to the lowest possible point. The office of *Præfectus Horti* was abolished, Lindley left, lectures were discontinued, artificial heat for cultivation was abandoned, all labour was paid off except such as was absolutely necessary, and the garden relegated to the care of the Curator. The examinations for prizes were still continued however, being conducted after Ward's resignation by Dr. (afterwards Sir) J. D. Hooker. Later in the year the construction of a new sewer along the north side of the garden necessitated a reconstruction of the buildings in use, which added materially to the difficulties of the situation. From this time onward till 1862 very little was done for the improvement of the garden, and its future destination remained in abeyance.

The University Colleges—Henfrey

The progress of botany under University teaching in London during this period was insignificant. We have seen that at University College Lindley still held the Chair, but with his other work, and the anxieties it entailed, he did but little for education. At King's College the Chair of Botany became vacant in 1841 by the death of Don. His successor, Edward Forbes, though a naturalist of great eminence, was far more attached to zoology than botany, though he had been a pupil of Graham at Edinburgh. He held the professorship at King's till 1854. Arthur Henfrey succeeded him and occupied the chair till 1859, when he died at the age of forty. He was attached to botany all his life, though his early studies were applied to medicine. Henfrey was perhaps most conspicuous as a writer in support of the developments of botany initiated by the German writers of the time, especially Von Mohl and Schleiden. He published several works on taxonomy, com-

municated numerous papers to the Royal and Linnean Societies, and wrote several articles in the *Micrographic Dictionary*, of which he was co-editor with Griffith. He brought out in 1857 an *Elementary Course of Botany*, which had a considerable circulation, and he translated Von Mohl's *Principles of the Anatomy and Physiology of the Vegetable Cell*, and Schleiden's *Principles of Scientific Botany*. In 1849 he established a magazine, *The Botanical Gazette*, but it only appeared for two or three years.

Henfrey carried out a certain amount of original investigation, but it was aimed chiefly at the corroboration of the discoveries of other botanists, particularly Amici on fertilisation in the Phanerogams, and Saminski on the same process in the ferns.

He was succeeded as Professor by Robert Bentley.

CHAPTER XLIII

THE DAWN OF SCIENTIFIC AGRICULTURE

THOUGH the close relationship between botany and agriculture could hardly have been overlooked in the early times, but little attention was paid to the connection between the two, and the early agriculturists were much more concerned with the practical than with the scientific aspect of their calling.

Pioneer work was done in 1523 by Fitzherbert, and in 1557 by Tassus, and for a long time their writings were held in high esteem. Translations of the classical authors were produced about the middle of the sixteenth century, and the writings of Xenophon and of Columella came into vogue. The whole literature of the subject at that time goes to show what an influence the classical writers had upon the practice of husbandry.

Practice was called in in some measure to supplement theory, but no doubt it was chiefly empirical. It is noteworthy that Francis Bacon gave experimental farming a certain impetus by his teaching.

The seventeenth century saw a certain advance both in practice and in theory, and many writers contributed something to the advance of knowledge. The work of Blith, the author of *The English Improver Improved*, was noteworthy, showing that more ambitious projects than the suggestions of the previous century were agitating the minds of the leaders of agriculture. Blith seems to have been very much in advance of his time, for he boldly suggested that agriculture ought to be a subject of study at the universities, and appealed to the higher ranks of Englishmen to give attention to the importance to it of applied science. In 1659 one Speed issued a series of abstracts of agricultural experiments, but they failed to command universal respect.

About the middle of the century the Royal Society was formed, and in its early records may be found much of scientific interest bearing upon the problems of husbandry. For almost the first time science and practice seemed to form an alliance. From this time date Evelyn's *Sylva* and his *Pomona*, to which we have already alluded. But a period of apathy followed, to be succeeded

by a further revival in the reign of George II. As we have seen, Professor Bradley was better known by his agricultural rather than his botanical writings. A further period of stagnation lasted till well into the eighteenth century. Agriculture was neglected by the landed classes, and with the exception of the writings of Jethro Tull little was done.

Nor was much progress made in the early years of George III. On the whole it may be said that it is to the period 1840-60 that we can trace the dawn of scientific agriculture in England. Earlier in the century the dependence of agriculture upon science had been realised in the main by a few eminent men only, but their ideas made but slow progress, and agricultural practice continued to be empirical. The first connection of the two was made by a chemist, and chemistry, rather than botany or vegetable physiology, remained the connecting link till nearly the forties. It was Sir Humphrey Davy to whom was due the first systematic attempt to apply scientific principles to the elucidation and improvement of agricultural practice. For ten years in succession, from 1802 to 1812 he gave annually a course of lectures on the subject; these were published in 1813 in the form of a book entitled *Elements of Agricultural Chemistry*, which passed through several editions. In these lectures he gave a fairly complete account of what was then known about agriculture, dealing not only with its practical aspect, but tracing the bearings of chemical science on the problems before the farmer. He took also some features of the physiology of the plant under review, dealing with its organisation, differences of temperature and illumination as affecting it, the influence of the composition of the atmosphere upon its life, and certain other general considerations. But to him, as to so many of the scientific agriculturists who followed him, the chemical problems offered a far greater scope and possessed a far greater importance than the physiological ones. The composition of the soil, the action of manures, the chemical composition of the various parts of the plant, the chemistry of fermentation, as far as it was then known, were fully examined.

In this way agricultural science was at the outset rather one-sided. The botanists made no great effort to draw attention to the physiological peculiarities and needs of the plants of the farm, and it cannot be wondered at that for a very long period agricultural science meant little more than the chemistry of the soil, and of the manures supplied to it. It was not till the advent of Daubeny on the scene that matters became more evenly balanced,

and it may be said that he practically founded scientific agriculture in England.

Daubeny's career brings us back again to the University of Oxford, and shows us its influence growing and extending in a new direction. The death of Professor John Sibthorp was followed by the uneventful professorship of Dr. Williams, and on his decease in 1834 new life was stirred up in the botanical school.

Charles Giles Bridle Daubeny was born at Stratton in Gloucestershire in 1795, and was educated at Winchester. Subsequently entering Magdalen College, Oxford, he graduated B.A. in 1814, and was shortly afterwards made a Fellow. For three years after taking his degree he studied medicine at Edinburgh, but soon left it for scientific pursuits. He was very versatile, distinguishing himself in geology, chemistry, and botany. In his earlier days the first of these engaged his attention very conspicuously; he was much interested in the study of volcanoes on which he wrote a very valuable book in 1826, bringing forward a theory of volcanic action which had much to recommend it.

In 1822 he was elected to the Professorship of Chemistry at Oxford. He then proceeded to the degree of M.D. there, and practised medicine till 1829. He spent some time in France, and, in 1830, studied botany under Alphonse De Candolle, with whom he formed a cordial friendship. He attained a considerable reputation in the subject, and on his return to Oxford found this very serviceable. He retained the Chair of Chemistry till 1855, but he did not confine his interests to its duties, for plurality of offices being then possible at Oxford he was elected to both the botanical professorships during his tenure of this one. He was made Sherardian Professor in 1834, on the death of Williams, and took the Sibthorpian Chair of Rural Economy in 1840. It is a little singular that his more important botanical work was not done till he had become professor.

His first paper that bears on agriculture was on the action of light on plants, and the action of vegetation on the composition of the atmosphere. In it he estimated the relative value of the rays of the spectrum on the process of the appropriation of carbon dioxide by the green plant, and introduced the method of passing the incident light through screens of different coloured glass. In this memoir he showed an appreciation of the possession of sensitiveness by plants, for he said: "Light acts on the vegetable as it does upon the animal kingdom, in the character of a specific stimulus." When he took the Chair of Rural Economy his work

became more directly agricultural, and in his lectures he dealt with chemical as well as botanical problems. His first lectures as Sibthorpian Professor were given in 1840. In them he laid great stress on the importance of the study of botany and physiology as well as chemistry for a proper scientific equipment of any one who proposes to attempt the elucidation of agricultural practice, thus bringing the several sciences into a more even balance, and showing that research in agriculture must go further than the problem of the composition of the soil. He treated of the constitutents of the different crops, and examined the question of their sources; of the principles involved in the application of manure, and of the rotation of crops and its relation to the physiology of the plant as well as the constituents of the soil. His geological leanings led him to discuss, or rather to speculate upon, the possibility that volcanic action might have been the original cause of the appearance of combined carbon and combined nitrogen. He continued to give lectures on various branches of Rural Economy for twenty-five years.

He applied the method of experiment to agricultural study. In 1845 he attempted by it to elucidate the principles involved in the rotation of crops, carrying the researches out on special plots of ground in the botanic gardens. Not unnaturally these experiments were made chiefly on the constituents of the ash of plants. He bequeathed to his successors in the Chair, for experimental purposes, a piece of ground of about 1½ acre in extent, feeling, he said, that the objects of the foundation of the Professorship of Rural Economy "would not be fully attained until the holder of it was enabled not only to retain the information he might obtain from books, but also to illustrate it by experiment, and to verify as well as extend the knowledge he might have derived from others through original investigations of his own."

He was the first to show the difference between the total amount of the salts contained in the soil, and the amount available for use by the plant, a problem of great importance to the farmer, and of interest to the physiologist, and one which has been the subject of a good deal of experimental inquiry in recent times.

Perhaps his discernment was best displayed in his paper on the influence of the lower vegetable organisms in the production of epidemic diseases, published in the *Philosophical Transactions* for 1855. In it he adopted and supported with great acuteness the fungus theory of disease, giving reasons for believing that the organisms concerned are extremely minute. He set out as an

object calling for research the determination how far the growth of the fungi which attack different crops may be considered as a cause or only the effect of disease. In 1857 he published a course of lectures on Roman Husbandry, to which he added a catalogue of the plants mentioned by Dioscorides, arranged in the modern natural orders.

He was a strong supporter of Darwin's views on Natural Selection. In 1860 he read a paper on the Sexuality of Plants at the British Association, in which he argued strongly in its favour. He set before himself the problem: "Whether growing plants year after year on the same land from the seed yielded year by year tends to variation or to the obliteration of specific characters," but he was unable to submit it to the test of experimental research.

Daubeny was one of the first Members of the British Association, and became its President at the Cheltenham meeting in 1856. Fifteen years previously he had presided over the chemical section at the Plymouth meeting. At the first meeting, held at York in 1831, he was the only representative of the universities of England. An interesting circumstance marked his Presidency, for his Gloucestershire friends caused a medal to be struck in his honour and presented to him. Such an occurrence has never been repeated.

His other work was perhaps hardly so important as might have been expected, though he wrote several books and memoirs, chiefly on agricultural subjects. He wrote also "An Essay on the Trees and Shrubs of the Ancients," together with other botanical papers, the total number of them being nearly a hundred.

But Daubeny's work in agriculture was by no means the measure of his activities at Oxford. Under him the botanic garden underwent considerable alteration and development. Under his predecessor it had fallen into a very bad condition, and needed the expenditure of a considerable sum of money. Dr. Williams had left by will a sum of £500 to be the nucleus of a fund for that purpose, and Daubeny threw himself with much energy into the scheme, ultimately raising about £3000. Two-thirds of this amount were spent on the garden and greenhouses, and the remainder on the buildings in which were housed the library and the collections.

The garden was consequently extended in area, and made both beautiful and attractive. Moreover, its contents were re-arranged, the Linnean system being followed in the eastern half, and the

De Candollean in the western. New houses were added gradually, the next few years seeing considerable activity. For the whole of his life, indeed, Daubeny was solicitous for its prosperity. The plan of its arrangement gradually departed from the Linnean system, but the latter had not disappeared when, many years later, Professor Bayley Balfour on his return remodelled the systematic herbaceous beds.

Another new departure, which was originated by Daubeny, was the foundation of a botanical museum. This was begun in 1859, and was meant to be supplementary to the herbarium. It was not arranged at all on a pretentious scale, specimens of fruits, seeds, stems, roots, and other plants being preserved in cases in a room which had been for some time disused. Certain economic products also were represented. It did not, however, attain large proportions, and after Daubeny's death fell into neglect.

It is interesting to note that during Daubeny's professorship Dr. Maxwell Masters was for some time Sub-Curator of the Herbarium.

Daubeny's experimental plot, which he bequeathed to the University for the purpose of agricultural research, was greatly neglected after his death, and its original purpose was gradually abandoned. Difficulties connected with the tenure of the Sibthorpian chair arose, and regulations were made restricting its occupancy to three years. No funds were forthcoming to aid the Professor in carrying out research, and thus Daubeny's scheme broke down. Eventually, at the end of the century, the plot and building were sold to the speculative builder.

Daubeny died in 1867, at the age of seventy-two. He was a man of earnest spirit, impartial in his opinions, and given to express them without fear or favour. He was at once firm and gentle in temperament, prudent and generous in his dealings with others, and of a cheerful and sympathetic disposition. While he took up a departure in science almost entirely new, he was never indifferent to the opinions of others, and never prejudiced in favour of his own.

Lawes and Gilbert and the Rothamstead Station

But the advance of scientific agriculture owes very much more to one of Daubeny's pupils than to himself. The name which claims the first place in England in that direction is that of John Bennett Lawes, the founder of the famous experimental station

at Rothamstead in Hertfordshire, who as a small landowner began agricultural management about the year 1834, being then twenty years of age. He had studied under Todd Thomson in London, and at Oxford had been one of Daubeny's students. In his early studies he had come under the influence of the *Recherches chymiques sur la Végétation* of the great Swiss botanist, De Saussure, and had even then made up his mind to attempt to solve experimentally some of the problems which were therein suggested.

The researches which had followed those of Davy had been in the main concerned with the condition and function of the humus in the soil. Thaer claimed that the fertility of a soil depended on the amount and character of the humus that it contained, holding that it supplied all the plant required except water. He proved that this humus is the residue of previous vegetation, which had not been removed in the crops, and that its composition is consequently varied in its character, while it yields more and more extractive matter as time brings with it increased exposure. The questions of manuring had been studied and written of by Sprengel during the years 1825-40. From 1834 onwards Boussingault, the great French physiologist, had applied himself to research, and had taken up the examination of humus in more detail, particularly its nitrogenous constituents, examining also the influence of rotation of crops upon its composition. In 1840 Liebig had published his great book on *Organic Chemistry in its Application to Agriculture and Physiology*, in which he showed the true nature and origin of humus, and proved conclusively that those writers were wrong who held the view that it is the source of the carbon which is a constituent of the plant's substance. This question, as we have already seen, had been dealt with by Priestley and by Ingenhousz, and much accurate information had been obtained by them, but in the course of time their work had fallen into neglect, and the later writers, like Thaer, had attributed combined carbon in the form of carbon dioxide to the humus as its source.

But the rôle of the salts supplied by the soil remained entirely unknown, and the source of nitrogen was disputed. On this last question Liebig and Boussingault were not agreed; the former held that it comes from the free nitrogen of the air, the latter that the soil supplies it in some combined form. Moreover, Liebig taught that the fertility of a soil depends upon the character of the mineral salts which exist in it rather than on the amount of combined nitrogen it contains. These problems attracted Lawes,

and as soon as he was able after taking the control of his property, he set to work upon them. He began his investigations upon the phosphates and particularly the supply and fate of phosphorus, led to the question by the observation that a superphosphate of some base exercises a beneficial influence on the turnip crop. In this connection it may be mentioned that he took advantage of his discovery to patent a method of preparing it, and so started those famous works for the manufacture of artificial manures which we associate with his name, and to which no small part of his subsequent wealth was due. The experiments were begun in 1837 and were conducted at first in pots, but after three years they were run on a larger scale in the open field. Three years later again, in 1843, he called in to his assistance Dr. J. H. Gilbert, a pupil of Liebig's, and thereafter science replaced empiricism. These experiments practically marked the beginning of Rothamstead as an agricultural station.

Gilbert was born in 1817 and was educated at Glasgow and University College, London, studying under Professor Todd Thomson as Lawes had done. Thence he went to Giessen and became a pupil of Liebig, taking the degree of Doctor of Philosophy. During part of 1840 and 1841 he was assistant to Todd Thomson in University College, and afterwards devoted himself to the chemistry of calico-printing, dyeing, etc., in the neighbourhood of Manchester.

The association of Lawes and Gilbert in the work at Rothamstead was most felicitous, and their names soon became prominent in the literature of agriculture, agricultural chemistry and physiology. The results of their researches were published continuously in various journals, including the *Philosophical Transactions* and *Proceedings* of the Royal Society, and secured the adhesion of men of science in all parts of the world. More than a hundred memoirs came from their pen, dealing with many of the most important problems of the time. They were all based upon experiments which were carried out under their immediate supervision.

The first problem to which they turned their attention was the source or sources of the combined nitrogen of the plant. As we have seen, this was at the moment a matter of somewhat acute controversy, Liebig and his followers holding the supply to be atmospheric, while Boussingault and his school attributed it to the compounds of nitrogen present in the soil. Their researches aided materially in the establishment of Boussingault's views.

We cannot, however, go fully into the work achieved at Rothamstead, for most of it belongs to a later period than that now under consideration, and must be deferred to a subsequent chapter. We are concerned for the moment with the establishment of the experimental station, and the influence it exerted on the progress of research in the years prior to 1860.

Lawes set apart separate fields of the Rothamstead estate to the cultivation of particular crops, which were grown year after year in succession under constant conditions of manuring. Each field was divided into a number of separate experimental plots, each of which was devoted to the examination of the results of applying particular applications of fertilisers in every succeeding year. In other cases definite rotations of crops were examined. The aim of the researches was thus to determine the principles of successful agriculture and the practice which was best adapted to carry out those principles to commercial success.

Side by side with these more technical operations, the scientific questions of the day as they affected agriculture were examined from the scientific standpoint. Much valuable information was thus obtained on the physiology of both plant and animal, and the fame of Rothamstead as a scientific institution spread far and wide.

A laboratory was built in 1853, by public subscription, as a testimonial to the value of the work which, even so far, had been achieved. This played no small part in the future development of the station, gathering together a number of workers whose researches in later years were of the first importance.

Both Lawes and Gilbert attained to high honours in the world of science. Lawes received the Fellowship of the Royal Society in 1854; Gilbert in 1860. Both were awarded honorary degrees by the leading Universities. Lawes was made LL.D. (Edinburgh) in 1877; D.C.L. (Oxon.) in 1892; Sc.D. (Cantab.) in 1894. Gilbert was created LL.D. (Glasgow) in 1883; M.A. (Oxon.), 1884; LL.D. (Edinburgh), 1890; Sc.D. (Cantab.), 1894. Lawes was made a baronet in 1882; Gilbert was knighted in 1893. Jointly they received a Royal Medal from the Royal Society in 1867. In collaboration they published seven papers in the *Philosophical Transactions*. In 1893 the Liebig Silver Medal was awarded to them jointly by the curators of the Liebig Foundation of the Royal Bavarian Academy of Sciences. In 1894 the Albert Gold Medal of the Society of Arts was presented to them in special recognition of their researches at Rothamstead.

At about the time when Lawes was contemplating the researches

of which we have spoken, the spirit of inquiry was being evoked among agriculturists in other parts of England, and an effort to co-ordinate their activity took the form of the establishment of the Royal Agricultural Society of England. This was largely due to the activity of Sir H. S. Meysey Thompson, a country gentleman who was from his youth always devoted to agriculture. He contributed largely to its establishment and wrote many papers in its *Journal*. After 1855 he acted for some years as Editor of the latter, and subsequently as Chairman of the journal committee. In 1843 Dr. Lyon Playfair (afterwards Lord Playfair) was made consulting chemist to the Society, a post he held for five years. In 1848 he was followed by Professor Way, and he in turn, ten years later, by Professor Voelcker.

It may not be out of place to mention here that scientific experimental work was started in 1877 by the Duke of Bedford on behalf of the Society at Woburn.

Contemporary Botany in Scotland and Ireland: J. Hutton Balfour at Glasgow

The removal of Sir W. J. Hooker was a sad blow to the progress of botany at Glasgow. None of his predecessors had raised the reputation of the Chair to the height which it had attained under him, though indeed the reputation was personal to himself. The garden had been the object of his solicitous care, the teaching had been organised and carried out in such a way as to redound greatly to his credit, while his contributions to literature had been unique in the history of the University. Nor was his work altogether finished when he went away, for he had during his last few years inaugurated a movement that was only brought to a successful conclusion after his departure.

His successor was Professor John Hutton Balfour, afterwards for many years the occupant of the chair at Edinburgh with which his reputation was more closely connected. Born in 1808, he was educated at Edinburgh and subsequently at the Universities of St. Andrews and Edinburgh, in the latter of which he graduated as M.A. and M.D., taking the last degree in 1832. At first he intended to enter the Church of Scotland, but he changed his mind and, preferring medicine to theology, graduated and practised in Edinburgh as a physician from 1834. In his student days he was a pupil of Graham, and was by him attracted to the study of botany. As we have already noted, he was prominent in the

founding of the Botanical Society of Edinburgh in 1836, and two years later he helped to establish the Botanical Club. It may be mentioned here that the library and herbarium of the Botanical Society were ultimately acquired by the Crown, and became the nucleus of the collection now in the Royal Botanic Garden. In 1840 his attachment to the subject led him to undertake a course of extra-academical lectures, which were well attended and were altogether a great success. He thus showed himself a man of considerable promise and was, perhaps, in consequence, invited to follow Hooker in the Glasgow chair, a task, however, which might well have daunted any one then living.

He was at once called upon to take up and guide the course of the scheme which had occupied Hooker's thoughts for some considerable period and which he had already begun to agitate for. Owing to the great growth of Glasgow in a westerly direction, the garden at Sandyford, though not much more than twenty years old, was becoming so shut in by new streets and buildings of various kinds that its usefulness as a centre for botanical study was much impaired. The plants refused to grow, especially the more delicate ones. None too large in extent, possibilities of extension were absent, and development was therefore impossible. Besides, the growth of the city increased materially its value as a site, and suggested possibilities in the direction of procuring a larger garden.

So Balfour found the removal a pressing question, certain introductory steps having been already taken. A new site was selected and the new garden laid out on Kelvinside. Unfortunately, though beautifully situated in many respects, it left much to be desired from the points of view of soil and exposure. The collections of plants, and many of the old greenhouses were removed to the new site, to serve as the nucleus of further extensions.

This garden, like that at Sandyford, was not the property of the University, and the Professor, therefore, had not the opportunity of using its resources to the full. Moreover, he was not at liberty to form his plans with a free hand. The garden was more under Municipal direction, its ownership being associated with the Royal Botanic Institution of Glasgow, to whom a Royal Charter had been given in 1818.

Walker-Arnott

Balfour's stay at Glasgow was not a very long one, and little but the removal of the garden is connected with his name. In 1843 he applied for accommodation in the College for his dried

plants, an application that seems to indicate the absence of a herbarium. He resigned his Chair in 1845, having been appointed to succeed Graham as Professor of Botany at Edinburgh. He was followed at Glasgow by Professor Walker-Arnott, whom we have noted already as the severe critic of Don's systematic work.

Arnott's professorship was uneventful. In his earlier years he had studied law and had been actually admitted in 1821 into the Faculty of Advocates, but he abandoned the legal profession almost immediately afterwards and became a botanist. As a friend of Hooker he worked for some months in Paris (where he published two papers on Mosses), subsequently undertaking botanical tours in Spain and in Russia. In 1825 he accompanied Bentham in his botanical expedition to the Pyrenees. Between 1830 and 1840 he was closely associated with Hooker in the examination and description of the plants collected during Captain Beechey's voyage to the Pacific Ocean and Behring Straits. The results were published in 1841. Arnott was also engaged during these years independently in the publication of descriptions of new plants from South America, India, and Senegambia, together with other less important botanical work. Before Hooker's departure from Glasgow he assisted him in his academic work.

Arnott was further noted as an authority on Diatoms. He began the study of this group in 1850, and published several memoirs on the subject. He died in 1868. His botanical collections are now the property of the University of Glasgow, and formed the nucleus of the herbarium there. Arnott was succeeded in the chair by Alexander Dickson, at the moment Professor of Botany in Dublin.

J. Hutton Balfour at Edinburgh

On the death of Graham in 1845, as we have already seen, the important position of Professor of Botany in the University of Edinburgh, which was combined with that of Regius Keeper of the Royal Botanic Garden and Queen's Botanist for Scotland, was given to Professor J. Hutton Balfour of Glasgow, who held it with distinction till 1879. His term of office was comparatively uneventful, but he attracted students in considerable numbers, and became known as one of the most successful teachers of the period. His contributions to literature had a bearing more particularly on this side of botanical advancement, his textbooks being for

many years the standard works upon the subject. He published a *Flora* of Edinburgh and its environs in 1863, and an *Introduction to the Study of Palæobotany* in 1872. His teaching was very thorough, both in the field and in the classroom. With his students he explored during these years the greater part of Scotland, and he introduced the practical teaching of vegetable anatomy and histology into the University. The gardens were also to him a source of much concern, and to his solicitous care much of their progress and development was due. He was assisted in their management by the MacNabs, the younger of whom became associated later with the Irish school. There was nothing very startling to be noted during these years of slow but steady progress. Successively the palm house and the arboretum were established, and the garden was very considerably enlarged. Balfour was much esteemed among his colleagues. For thirty years he was Dean of the Medical Faculty of the University of Edinburgh, and the latter body as well as the University of Glasgow gave him the honorary degree of LL.D. When he retired from the duties of his Chair in 1879 he was made Emeritus Professor. He was succeeded by Alexander Dickson.

It was perhaps as a teacher that Balfour achieved his greatest distinction, though his administrative abilities were of a high order. He threw himself with whole-hearted zeal into the academic duties of his chair, and became the first Dean of the Faculty of Science in the University. He took up also the posts of Secretary to the Royal Society of Edinburgh, and Secretary to the Royal Caledonian Horticultural Society. He also engaged in much literary work, becoming editor of the *Edinburgh New Philosophical Journal* in addition to his work in connection with the affairs of the Botanical Society.

As a teacher, Balfour possessed in a high degree the power of exciting enthusiasm among his pupils. Under his management the botanical excursion took a much more prominent place in the curriculum than it had done under any of his predecessors. Not only did he encourage and develop a knowledge of the flora, but he inculcated in his students a much broader outlook, leading them to the consideration of those problems which are to-day assuming so great a prominence as to form a special section of Botany under the name of Œcology. He was the pioneer at Edinburgh of the practical examination of structure which was the basis of so much of the botanical study in England during the last two decades of the century. In this important branch, he organised

courses of instruction during nearly the whole of his occupancy of the Edinburgh Chair.

Among the products of his pen was his famous textbook, which was originally compiled for the use of his students, but which in due time became the leading handbook. It was long without a rival in Scotland, passing through several editions during his lifetime.

It was to his energy and foresight that the establishment of the museum, which is still so remarkable a feature of the Edinburgh garden, is to be attributed.

Falconer

Three other personalities of note call for commemoration here, friends of Balfour and distinguished botanists, working, however, rather in the foreign field. Hugh Falconer was born in 1808, and, after graduating at Aberdeen, studied medicine at Edinburgh, taking the degree of M.D. in 1829. He was chiefly concerned with the botany of India, in which dependency his scientific career was cast. Before going out from home he assisted Wallich in the distribution of his great Indian collection. He began active service as an Assistant Surgeon in the Bengal establishment of the East India Company, going out to Calcutta in 1830. It was not long before he was appointed to succeed Dr. Royle as Superintendent of the Botanic Garden at Saharanpur, a post he held for nearly twenty years. His work there was only partly connected with pure science, though he added largely to the knowledge of the Indian flora. Its more important results were economic, a notable incident being his investigation by experiments of the possibility of cultivating the tea-plant in India. The experiments were quite successful, and the first Indian tea was manufactured under his direction.

He made considerable collections of Indian plants, which he brought back to England. After much neglect, when he had returned to his post, they ultimately found their way to Kew, where they were incorporated in the herbarium.

Falconer succeeded Wallich as Superintendent of the Calcutta garden in 1848. While there he published, in 1850, a valuable report on the teak forests of Tenasserim, and later another on the quinine-yielding Cinchonas and their introduction into India. He was made a Fellow of the Royal Society in 1845.

Though he was thus actively engaged in botanical work he

achieved greater fame for his palæontological researches, on which indeed his reputation mainly rests. He died in 1865.

Muntz

Another distinguished botanist of Edinburgh training was Giles Muntz, one of the most famous of the pupils of Graham, under whose tuition he secured a gold medal for a collection of plants. After his preliminary training at Edinburgh, he went to Paris and studied under Adrien de Jussieu. His botanical work was chiefly concerned with the flora of Algiers, in connection with which he published two important works—the *Flore d'Algérie* of 1847 and the *Catalogus Plantarum in Algeriâ Nascentium* some years afterwards. The former was arranged on the Linnean system, and contained descriptions of 1800 species; the latter was a larger work and dealt with 2600 species, of which 800 were new.

Muntz resided in Algiers for five years, from 1839-44. He then returned to Scotland. He was an original member of the Botanical Society of Edinburgh.

Lindsay

Another botanist to whom we must refer was the great writer on the Lichens, W. L. Lindsay. Born in 1829, he was, like the others, an Edinburgh graduate, and studied medicine there. The thesis he submitted for his medical degree was a contribution to the knowledge of the anatomy, morphology, and physiology of the Lichens, and the group never lost its fascination for him. He wrote in 1856 a *History of British Lichens*, which won for him the first Neill Gold Medal which the Royal Society of Edinburgh awarded. In 1861-62 he visited New Zealand, and in 1868 he published some contributions to New Zealand botany. But the Lichens soon attracted him again, and in 1870 he published a further work upon their structure, *Memoirs on the Spermogenes and Pycnides of Lichens*. Besides these larger works he contributed many memoirs on the group to various scientific journals. Lindsay died in 1880.

Mention may be made also of Robert Dickson, another friend of Balfour's, who, though educated at Edinburgh, settled in London, and lectured on botany in the Medical School of St. George's Hospital. He died in 1875.

Botany at Aberdeen

The administration of the joint medical school of the two Universities of Aberdeen, founded as we have seen in 1827, led to strained relations between them, and in 1839 they decided to separate. Professor Knight resigned the charge of the botanical teaching in the conjoint school, and was succeeded at Marischal College by John Shier, who, however, only held the status of Lecturer. At King's College the subject was put into the hands of George Dickie, to whose *Flora Aberdonensis* we have already called attention.

Both Lecturers were able men. Shier soon devoted himself to agricultural chemistry, and after holding the first Fordyce Lectureship in Agriculture became Agricultural Chemist to the Colony of Demerara. Dickie remained at Aberdeen till 1849, when he was elected Professor of Natural History in Queen's College, Belfast.

One of the most famous of the Scottish naturalists succeeded to the Chair of Civil and Natural History at Marischal College in 1841, in the person of William McGillivray. He was born at Aberdeen in 1796, and was educated there, graduating in King's College in 1815. He was an ardent devotee of natural history from his youth, generally spending his vacations in its pursuit. As early as 1819 he undertook to lecture on botany, but went to Edinburgh to pursue his studies. While in Edinburgh he published, among other works, a *Manual of Botany* and an abridgment of Withering's *Arrangement of British Plants*, which subsequently went through several editions. He devoted himself, however, with still greater energy and enthusiasm to zoology, becoming one of the foremost naturalists of the time. It was to this feature of his reputation chiefly that his appointment to the Chair was due. He held the Professorship for eleven years, teaching zoology and geology in the winter and botany in the summer during the whole of that period, and laid the foundations of a natural history museum with collections of the local fauna and flora, which were the products of his class excursions.

McGillivray's writings dealt more particularly with zoology, in which his greatest interest lay. It was incidentally, therefore, that he was concerned in the progress of botany. Unhappily his life was cut short by pulmonary trouble, and after a very active service of about eleven years he died in 1852.

It is very interesting to read in his *Manual of Botany*, published in 1840, certain speculations upon classification and the limits

of species, in which he shows us that his mind was travelling over much the same ground as that of Charles Darwin, and hinting at conclusions which, though he did not formulate them, were quite in accordance with the views which found expression in the Origin of Species.

McGillivray's herbarium is now preserved in the University of Aberdeen.

Nicol, the successor of McGillivray in the Chair of Natural History in Marischal College, was attached almost exclusively to the zoological side of biology. The botanical teaching was at first put into the hands of Wyville Thomson, who had the status of Lecturer only. He was succeeded by others, but no one held the post for long, and no one contributed to the advancement of the subject. So matters went on till 1860. Nicol remained Professor of Natural History until his death in 1878.

At King's College, matters were little more satisfactory. When Dickie went to Belfast in 1849-50 Christie was made lecturer in botany; he was succeeded by Wyville Thomson in 1851, and he in turn by Crombie Brown, who discharged the duties from 1853-59.

The subject was thus administered at both colleges by lecturers, and was practically altogether overshadowed by zoology, which almost came to stand for natural history. The condition was satisfactory to no one, and after considerable negotiation it was terminated by the fusion of the teaching at the two centres, as a result of which a new Chair of Botany was established in the University, and from 1860 onwards the subject has been under the charge of a distinct professor.

The first Professor was Dickie, who returned from Belfast to hold the Chair. Progress was soon apparent; in the same year, 1860, he published a local *Flora* of the counties of Aberdeen, Banff, and Kincardine. But encouraging as were the prospects of the new Chair at first, a cloud soon came over them. Dickie's health gradually failed, and he was compelled to resign his professorship in 1876, without having accomplished what he put before him. His successor was Professor James W. H. Trail, F.R.S., who still occupies the Chair.

Dickie was a man of considerable reputation, being a Fellow of both the Royal and the Linnean Societies. His early work was concerned mainly with the morphology and physiology of plants. His local *Flora* shows also a leaning towards taxonomy. During the latter part of his life, indeed after 1844, he was chiefly interested

in Algæ, and was esteemed one of the chief authorities on that group. He was entrusted with the important task of working out the Algæ of the *Challenger* expedition.

Harvey

The years 1843-46 were eventful in botanical circles in Dublin. In 1843 Coulter's services to the herbarium were cut short by his death, and Professor W. Allman vacated the University Chair of Botany, retiring into a brief spell of private life which was cut short by death three years later. Disaster befell Glasnevin too, for Litton passed away in 1846.

These untoward events led, however to very important developments, the most prominent of which was the appearance on the scene at Dublin of a man who stood in the very foremost rank among contemporary botanists, and who became easily the most famous of British algologists. His early career was clouded by much discouragement and his work done under great difficulty, yet when the moment came he emerged from comparative obscurity and took his place as the most famous of all those whom Ireland has contributed to the ranks of botanical investigators.

William Henry Harvey was born in 1811 at Limerick, where his father was engaged in mercantile pursuits. He was educated at a local school, where he came under the influence of a naturalist of some local fame, and speedily showed that he possessed considerable taste for natural history. It would be easy to overestimate the result of his schoolmaster's influence upon him, but no doubt it had a great effect at that impressionable age. The field of natural history to which he showed the greatest leaning, was strangely enough the little-known group of the Cryptogams, plants which attracted but few among systematists, but which afforded Harvey the employment, and yielded him the triumphs of the greater part of his life.

After leaving school he joined his father in business, but never ceased even then to cultivate what had become a hobby, the collecting and naming of marine specimens, both botanical and zoological.

When he was twenty years of age his bent towards botany was strengthened by his discovery of a moss which he thought was new to Ireland. He sent his specimen to Hooker at Glasgow, and named it *Hookeria lætevirens*, in token of his regard. In this way he made an acquaintance which he found of the first value and

which had an important influence on his career. A friendship soon sprang up between the two, and Harvey became a frequent visitor to the Glasgow school and was associated very closely with the Professor in botanical work, both literary and practical. Hooker recognised the promise of the young Irishman, noted his critical ability, and gave him active help as well as encouragement. During these years Harvey worked at the Cryptogams of Ireland, contributing his results to the *Flora Hibernica* which was published by Mackay in 1836.

On his father's death in 1834 Harvey relinquished mercantile pursuits and devoted himself more seriously to botany, electing to make it his life-work. He set out to enlarge his field of view by taking part in the great work of colonial exploration which others had cultivated with so much success. His eyes were turned at first to the Australian region, but family affairs ultimately led him to Cape Colony. Here he had, moreover, an almost untilled field, for the flora of South Africa had been scarcely at all explored. With the exception of two visits home, both paid under distressing conditions, Harvey remained in South Africa for seven years, during the latter part of the time holding the position of Colonial Treasurer.

His enthusiasm was remarkable, and easily outlasted his health. He explored the flora of large districts, and arranged for supplies of plants to be sent to him from various parts of the country; he sent descriptions of many new and rare forms to Hooker's *Journal of Botany*, and indeed, laid the foundations of the two great works which occupied his last years, the *Flora Capensis*, and the *Thesaurus Capensis*—monuments to his energy and skill. He published in 1838 his first great work, a forerunner of the *Flora Capensis*, a volume of *Genera of South African Plants*. His early attachment to the Cryptogams was not allowed to perish under the stress of this phanerogamic work, however, for in his last year in Africa he prepared his earliest work on the seaweeds, his *Manual of British Algæ*, the first of the volumes on which rests in the main his great reputation of to-day.

His South African career came to an end in 1842. He had already found it necessary once to visit England to recruit his health, and a second breakdown decided him to return for good. So the year 1843, the year with which we began this chapter, saw him taking up his abode again in Ireland, with the dismal prospect before him of embarking again on the sea of commercial life.

But his great reputation as a botanist drew towards him the

thoughts of the authorities at Trinity College, and, when William Allman resigned, there was a strong feeling that Harvey should succeed him. Unfortunately the "dead hand" interposed an obstacle. One of the conditions of the tenure of the Chair was that its occupant should be a fully qualified physician, and this qualification he lacked. The University authorities conferred upon him the honorary degree of M.D., possibly with a view to his candidature, but the adherents of the letter of the law were too powerful, and Harvey was passed over. The death of Coulter caused in the same year a vacancy in the Keepership of the Herbarium, and he was at once appointed to fill it.

This post was probably more to his mind at the moment than the Professorship. It gave him a sphere of action which was thoroughly congenial, and he threw himself into it with such energy that he may be said to have practically refounded the herbarium. He presented to it his own large collections, amounting to about 10,000 specimens; he added large numbers of plants from Sir W. J. Hooker's duplicates, and from Drummond's collections in the Swan River Colony; and he purchased for it and incorporated in it several smaller collections. He obtained the assistance of a large number of botanical correspondents, who supplied him with specimens from various regions. So great indeed was the energy that he displayed, that before the end of his first year of office he had added to the collection nearly 4000 plants. In succeeding years Trinity College aided him by making grants of money which he applied to such advantage that after about eight years the herbarium contained about 45,000 species of exotics, besides British species and a collection of Cryptogams. He selected his specimens with great care and discrimination so that the collection rapidly assumed a critical character, most of the orders being represented by their most appropriate types. Among the Cryptogams the Algæ of Beechey's voyage in the Antarctic seas occupied a prominent position.

During this period of Harvey's life he never lost sight of what was to him the great object of his ambition, the investigation of the Cryptogams, and in particular the Algæ. His vacations were devoted largely to explorations made along the coast, and to examination and description of the material thereby accumulated. His great work, the *Phycologia Britannica*, owes its inception to this period, its publication commencing in 1846.

The death of Professor Litton in 1848 caused a vacancy in the tenure of the Chair established by the Royal Dublin Society, with

which was associated the charge of the garden at Glasnevin, and Harvey was chosen to fill it. To his work here, reference will be made more fully later. In 1849 he undertook a long American tour in the course of which he gained the friendship of the leading men of science in the United States, and, what was, perhaps, more important, he accumulated material which ultimately became the foundation of a great work on American seaweeds. He did much of the actual collecting himself, and was materially helped by many correspondents, who sent him fresh accumulations as time went on. He also explored the phanerogamic flora in particular regions.

The year 1850 was marked by much activity in the pursuit of algology. He had returned to Dublin in the early part of the year and at once proceeded with his exploration of the coasts, collecting and describing species with his accustomed energy. The culmination of his work on the British seaweeds came in 1851 when the fourth and final volume of the *Phycologia Britannica* appeared.

In 1853 Harvey started on a prolonged tour to the East; his route included Egypt, Ceylon, Singapore, Australia, New Zealand, and sundry of the islands of the Pacific, and he returned ultimately by way of South America and Panama. The journey was originally undertaken in the interests of the herbarium and resulted in a large addition to its treasures. His extensive collections contained a huge mass of material, all of which was practically new. He took all available opportunities of exploring the Algæ of the different coasts to which he had access and amassed such a wealth of material that the collection was unequalled by any other of the time. The use he made of it is shown by the great *Phycologia Australica* which occupied him for five years after his return.

Harvey's absence from Ireland lasted three years, and on his return in 1856 he found himself confronted with a situation similar to that which had resulted in his succeeding Coulter in 1844. The Professor of Botany in the University, G. J. Allman, to whom reference will be made shortly, had just removed to Edinburgh to fill the Chair of Natural History, and the selection of his successor was imperative. Harvey again became a candidate and so highly had his reputation been enhanced that no opposition was raised to his election by the adherents of the insistence upon the medical qualification. Henceforth he held both Chairs of Botany in Dublin with the care of the herbarium and the supervision of both the botanical gardens.

It is to this period of his life that most of his more important contributions to literature may be referred. He gave up the field for the study and for administrative duties. His work in connection with his professoriate under the Royal Dublin Society was a source of some anxiety, great changes being initiated during the years from 1853 onwards, changes which were opposed by the Society and which led to friction. But these will be alluded to later.

During a large part of this time Harvey was at work upon the collection of Australian Algæ, which ultimately formed the basis of the *Phycologia Australica*. In 1858 he began to arrange his records of his South African plants, put together with so much skill many years before, and now intended to form the foundation of a *Flora Capensis*, a work in which he was assisted by Dr. Sonder of Hamburg. Harvey's own collections were supplemented by contributions of dried plants from various sources in South Africa, official and unofficial, and volumes of the *Flora* were published as they were completed. Simultaneously he was at work at the *Thesaurus Capensis*, but neither of these works was completed at his death.

Harvey married in 1861, unfortunately nearly at the end of his activity. His assiduous attention to his many labours, administrative and literary, proved too much for his health, which gradually gave way during 1864 and 1865. He was compelled to relinquish active work in March 1866, and he moved to Torquay hoping to recuperate. But the change came too late; he died there less than two months later.

As a botanist Harvey was certainly the most conspicuous figure that Ireland has produced. No isolated worker, but in touch with all the leading spirits of his time—Robert Brown, the elder Hooker, Greville, Bentham, Asa Gray, were among his friends. To the Trinity College herbarium he did inestimable service, and his loss was irreparable. His singular modesty comes out in one of his letters of 1852, in which he says of his work at the herbarium: "Here at Trinity College, Dublin, I sit like a turnspit roasting the meat, and when I am gone I suppose another dog will be put in my place." But with all this self-effacement he practically founded the herbarium as it is to-day.

His early life, spent in part on the coast of County Clare, where even as a schoolboy he collected marine Algæ, doubtless had much to do with his subsequent devotion to algology. The historically interesting manuals of Turner, Dillwyn, and other botanists of the early years of the nineteenth century were brought up to date by

the publication in 1841 of his *Manual of the British Algæ*, followed in the years 1846-51 by the well-known classic the *Phycologia Britannica.* This magnificent work, published at first in parts, offering a synopsis and full description with synonymy and distribution of every known British seaweed, illustrated by nearly 400 coloured plates, his own work, has not even yet been superseded by any more modern exposition of the subject on a similar scale. Even if it stood alone, it would afford ample grounds for claiming for Harvey a place in the foremost rank of the pioneers in British systematic botany. But it is far from being a solitary record; his work among the Australian Algæ is well worthy of comparison with it. He published *Nereis Australis* in 1847, and later gave the world the fruits of five years' work (1858-63) in the *Phycologia Australica.* He also published the *Nereis Boreali-Americana,* dealing with the American Algæ, which appeared in 1858.

He was possessed of extraordinary powers of discrimination, description, and illustration; his work, indeed, was mainly descriptive and not classificatory. While he was a quick worker and very clear in his writings he was not a great theorist, and exercised but little influence on the course of opinion on any of the movements of the time. When we remember the time at which he lived we can understand the lines on which his algal work was cast. It was unsurpassable in the direction which it took; clear and analytical, presenting tersely the diagnostic features of the species with which it dealt. The study of life histories and the minute details of histology which have attained such importance in recent years had not then come into prominence, nor were the methods of technique understood. Much of Harvey's work consequently may, perhaps, seem empirical, but it was such empiricism as served as a basis on which later writers could build a classificatory system.

G. J. Allman

But we must return to the events of 1844. As we have seen, Professor William Allman resigned his chair, and the effort to put Harvey into his place was unsuccessful. G. J. Allman, a graduate of Trinity College, was elected to the Professorship. Though of the same name as his predecessor he was not related to him. He was born at Cork in 1812, and was educated at Belfast, passing on to Trinity College, Dublin. Like so many botanists of the time he was a qualified physician, and his scientific tastes were

largely zoological. He was made a Fellow of the Royal Society in 1854, and in the next year removed to Edinburgh, where he was elected to the Regius Professorship of Natural History, and made Keeper of the Natural History Museum, posts much more congenial to him than the one he had held at Dublin. In later life he served on the Council of the Royal Society, from 1871-73, and was awarded a gold medal in the latter year. He was President of the Linnean Society from 1874-81, and was President of the British Association at Sheffield in 1879. Besides these honours he was awarded gold medals by various Societies. Mainly a zoologist, he exercised very little influence upon the progress of botany in Ireland.

The Botanic Gardens at Dublin

We have seen that at the commencement of this period Mackay held the Curatorship of the gardens at Ball's Bridge. He continued to occupy this post till his death in 1862. During the latter part of his life the gardens underwent a further extension, two acres being added in 1848 as a shelter-belt along the Lansdowne Road. This addition increased the area to about eight acres.

Mackay's services to science received some recognition in 1850, when the University of Dublin conferred upon him the honorary degree of LL.D. Though his work centred mainly in the gardens he contributed largely to Sir J. E. Smith's *English Botany*. His herbarium is still preserved in the collection at Dublin; it contains several species which, at the time he discovered them, were new to the British Isles.

During the period now under review, great and important changes took place in connection with the management of the Glasnevin garden and its administration by the Royal Dublin Society.

At the death of Litton, Harvey was appointed, as we have seen, to the vacant Chair, a post he continued to hold while he was Keeper of the Trinity College Herbarium, and after his appointment to the University Professorship. While he held the Chair he gave two courses of lectures annually, one at the Royal Dublin Society's house, Kildare Street, and the other at Glasnevin, till the changes of 1854 were brought about. Certain structural improvements were effected at the gardens; the orchid house was built in 1854, and in the next year the *Victoria regia* house was completed. Parliament voted a special grant of £1000 towards the former object. The first palm house was built in 1862. In 1853 the

Society transferred to the gardens an old building of iron which had been erected for the Exhibition of 1850, and devoted it to the purpose of a Museum of Economic Botany. This was a new departure, due to the initiative of the then Director, Dr. Moore.

In 1845 the Department of Woods and Forests decided to create in Ireland an institution similar to the Museum of Practical Geology in London, an object which was extended in 1847 to include the whole range of the industrial arts. It was to bear the name of the Museum of Irish Industry and Government School of Science applied to Mining and the Arts. On its establishment it was housed in Stephen's Green. In 1853 its control was transferred from the Office of Woods and Forests to the Department of Science and Art. Several professorships were established with it, giving prominence to its educational side. The Royal Dublin Society opposed the scheme with energy and persistency, realising how it threatened the educational work in which they had been so successful. Eventually a kind of compromise was arrived at, and a special committee was constituted, which was charged with the general arrangement of the lectures common to the two institutions, and they had charge of them till 1865. Like most compromises the arrangement satisfied no one, but nothing better could be agreed upon for several years.

In 1865 a further change was initiated which had at least the merit of doing away with this divided control. The Royal Dublin Society was placed in the position of Trustees for the administration of the Parliamentary vote; the Government undertook certain duties which included the complete support of the botanical garden at Glasnevin, and the museum and herbarium that had become associated with it. The Museum of Irish Industry was abolished, and its building in Stephen's Green was converted into a College of Science. The Committee of Lectures also disappeared.

These changes took some time to complete, but in 1867 the Royal College of Science was opened, and its administration placed under the supervision of a Council of professors, Dr. Alexander Dickson holding the Chair of Botany, which had not been filled up since Harvey's death.

The herbarium in the Glasnevin gardens was enriched by Litton's collection of plants, which the Society purchased in 1847 after his death, but it never attained the importance of the rival collection at Trinity College.

It may be noticed here that Glasnevin Gardens were thrown open to visitors on Sundays in 1861.

CHAPTER XLIV

CRYPTOGAMIC BOTANY IN ENGLAND

THE period which witnessed the activity of Harvey in Ireland and Dickie in Scotland and which resulted in such large accessions to knowledge of the Algæ, also saw the progress of research among the lower plants in England.

There were two botanists who laboured in this direction with conspicuous success, the bulk of whose work fell into this period, and who call accordingly for notice in the present chapter.

Wilson

William Wilson was born in 1799, and being introduced as a young man of twenty-two years of age to Sir J. E. Smith, imbibed from him a taste for botany, which led him to devote his life to the subject. He came a little later under the influence of Henslow, who in turn in 1827 introduced him to Sir W. J. Hooker. The activity which was then visible at Glasgow under the professor's stimulating example soon affected Wilson, and at the suggestion of Hooker he took up the study of the Mosses, and from 1830 onwards he devoted himself to the examination of the group.

Wilson's life was an uneventful one; he made no discoveries of sensational character; his work being taxonomic and not structural. The curious life history of the moss did not receive any elucidation from him. His principal work was the publication in 1855 of the *Bryologia Britannica*, which was intended to be a third edition of Hooker and Taylor's *Muscologia Britannica*. He wrote certain memoirs and collaborated in the publication of other floras, but never took any very prominent part in scientific work.

Berkeley

The second name which calls for notice here is that of the Rev. Miles J. Berkeley, whose researches on Fungi are so well known. He may be regarded as the virtual founder of British mycology. He was born in 1803 and educated at Oundle and Rugby, going thence to Christ's College, Cambridge, where he came under the influence of Henslow, and graduated in 1825. He was ordained in the following year, and like so many British botanists settled

down to the life of a country clergyman. From 1833 to 1868 he resided at King's Cliffe in Northamptonshire, being perpetual curate of Apethorpe-with-Woodnewton in the same county, and then he removed to the living of Sibbertoft.

His first work was done in connection with the Algæ, and he was not drawn to the Fungi till the publication of Smith's *English Flora*, to which he contributed the work on that group in 1836. This may be truly called an admirable production; it has earned encomiums from all mycologists of the first rank since its appearance. It was, however, only the first among many works on fungology. Between 1844 and 1856 he issued his *Decades of Fungi*, which fully held their own with any contemporary writings. After 1844 he began a very valuable series of memoirs on the diseases of plants and the pathology of the vegetable kingdom, which he contributed to the newly established *Gardener's Chronicle*, then under the editorship of Lindley. These were of course rather restricted in their scope; vegetable pathology was in its infancy and was not seriously considered outside the direct influence or parasitism of Fungi. Berkeley's studies on this aspect of the subject led him further as time went on; his work soon extended to the morphology and physiology of Fungi, the problems of which were suggested to him by the outbreak of the potato disease. With great skill he elucidated in 1846 the organism causing the disorder. His wider range of work soon found expression in two important books—an *Introduction to Cryptogamic Botany*, and the *Outlines of British Fungology* (1860). The former was the first comprehensive work on the subject in any language.

Two other important works must be mentioned. He described the Fungi collected during the voyage of the "*Beagle*," after Darwin's return, a work of considerable difficulty. He was associated with Bentham and Hooker in the preparation of the *Genera Plantarum*, where his classical scholarship was placed at their service to revise the Latin text.

Berkeley's eminence as a mycologist was fully recognised at Kew. From the time of Sir W. J. Hooker till his death practically all collections of exotic Fungi sent to the gardens were referred to him for description and classification.

Berkeley was made a Fellow of the Royal Society in 1879, but his connection with that body was of much older date, for a royal medal was awarded to him in 1863.

At the time of his death in 1889 he had amassed a large collection of Algæ and Fungi. The latter, comprising more than 10,000

specimens, were presented to Kew, while the Algæ were sent to the herbarium at Cambridge.

Berkeley's work was, on the whole, more taxonomic than structural. The investigation of Fungi from that point of view was only just beginning when he was in his prime. But he was easily first in the taxonomy of the subject, and was a pioneer in the new direction in his later work.

Thwaites

In connection with the work that was done on the lowliest forms of life, mention must be made of G. H. K. Thwaites, whose name will always be associated with the Diatoms. Thwaites was born in 1811, and spent his earlier years at Bristol, where he practised as an accountant. His first important departure in science was made when he was invited by Professor W. B. Carpenter to revise for publication the second edition of his *General Physiology*, a work that was of great service to many, and exercised not a little influence on current thought. This gave Thwaites a position which he justified by his researches into the nature of the group to which we have referred. He showed them to be vegetable in their nature, contrary to the opinion of the naturalists of the time. In the course of his studies on them he was able for the first time to recognise the process of conjugation. In his thirty-eighth year Thwaites was made Director of the Botanic Gardens at Peradeniya, Ceylon, where he made his mark by introducing the cultivation of Cinchona into the island. He was the first to observe the coffee-leaf fungus (*Hemeleia*), which afterwards caused such wide-spread devastation in the plantations.

Short as is the period considered in the present chapter it was essentially a time of progress. The study of botany was, during these years, directed towards a scientific basis, and while it devoted itself largely to the consolidation of the results so rapidly accruing, it opened the eyes of its followers to certain larger problems which demanded solution in the succeeding years.

The technical sorting of plants was no longer held to be identical with botanical science; the study of relationships, affinities, and such problems was attacked, and, though only at first with partial success, the minds of a few working in one direction in particular took shape at the close of the period in the magnificent hypothesis of Darwin and Wallace.

The spirit of scientific inquiry was abroad, not only in England,

but on the Continent of Europe; in several countries inquiry into systematic classification was the leading occupation of the time among botanists, and system after system was projected, sketched out, and abandoned in turn. The basis of them all was the De Candollean proposals, which, though by no means perfect, stood practically unchanged the test of examination and inquiry. The continental schemes made little impression on English thought; most of them were only ephemeral, but the *Enchiridion* of Endlicher took a firmer hold than the others. Except in a few particulars, however, taxonomy in England stood pretty much at the end of the period where it had been at the beginning. Much progress had been made in the study of the lower plants; monographs of many groups, often philosophically arranged, were published both at home and abroad. The activity of exploration was evidenced too in districts of the country, and the local floras had been made more numerous and more trustworthy.

The keen scrutiny that had been made by many investigators into the individuality and extent of genera had done much on the lines of so much of Linnæus's work; but while it had consolidated these groups it raised a most important question which neither then nor subsequently can be said to have been satisfactorily settled. "What is a species?" became a pressing question. The old idea of the fixity of species came under review; variation became a pressing problem; how far varieties differed from species—where lay the boundary line—and kindred problems—presented themselves for solution. So the period passed on to its successor the need of investigations, which falling into able hands made the years which immediately followed it the most important botanical science had so far seen.

A certain consolidation of the study had taken place on the Continent, however. So many schemes could hardly have been put forward without securing some advances. The idea that technical sorting of species constituted botanical science had gone, and had been replaced by methodical study of their individualities. Literature had been enriched by many books that stood out above the rest; Endlicher's *Genera Plantarum*, De Candolle's *Prodromus*, Knuth's *Enumeratio* were either completed or were far advanced. The study of the Cryptogams had made much progress, and plans for their classification on the basis of their inner structure were fast receiving acceptance. Moreover, standard floras of most European countries at least were continually appearing, arranged upon the basis of some natural method.

BOOK VII

THE ORIGIN OF THE MODERN REVIVAL

BOOK VII

CHAPTER XLV

DARWIN AND THE ORIGIN OF SPECIES

THE period between the years 1858 and 1880 stands out as the most memorable in the history of botanical science in England. It saw the greatest change that had ever taken place in the point of view from which the problems of taxonomy were regarded; it witnessed the dawn of a new physiological conception of the plant as a sensitive responsive organism. This led on to a detailed study of organic structure, which resulted in a more complete elucidation of the relations between structure and function, between division of labour and differentiation of body.

In the main these developments were due to the influence and work of one man, Charles Darwin, who not specially a botanist, rather a naturalist in the widest sense, exerted a greater influence upon botanical study and research than any of his predecessors.

This period brought to us also a broader view of the great vista of the object and purpose of taxonomic study, showing it as occupying itself not only with phylogenetic questions but also with the mutual relations of animated beings and physical phenomena, the great questions concerned with life upon the earth. To this great object exploration, philosophy, and literature were made to contribute.

In the preceding chapters we have noted how much earlier men had become dissatisfied with the principles on which classification was based, and have seen how this dissatisfaction grew with the progress of time in spite of protest—how the search for the true principles of classification was futile under the domination of the theory of special creation of species and their invariability or fixity, since no clue to natural affinity presented itself. Lindley in particular, in England had devoted many years of earnest thought and labour to the problem, had suggested various bases on which

to construct a scheme, but had been completely baffled. How near he came to the truth we may see in the following quotations from the *Vegetable Kingdom:* "That which really determines affinity is correspondence in structure." "It may be said that those plants are most nearly related which correspond in the greatest number of points, and those the most distantly in which we find the fewest points of correspondence, and this must be true when we remember that if every point in the structure of any two plants is found to be alike, then these two must be identical." This we may admit to be true, but it misses the foundation of such correspondence, the clue supplied by Darwin, the fact of a common descent, which Lindley and the men of his time did not grasp. The bewilderment of the systematists in the absence of this clue appears from some words of Lindley: "All the groups into which plants are thrown are in one sense artificial inasmuch as Nature recognises no such groups; . . . as the classes, sub-classes, alliances, natural orders and genera of botanists have no real existence in Nature, it follows that they have no fixed limits and consequently that it is impossible to define them. . . . Their characters are only a declaration of their prevailing tendencies." This was Lindley's last word after his prolonged devotion to the subject.

Nor was the progress of thought on the Continent crowned with greater success. Many systems had been promulgated since the proposals of De Jussieu and De Candolle, much familiarity with the different floras had been acquired. But the more modern work of Endlicher was not more satisfactory than the proposals of Lindley.

Another disturbing factor was beginning to make itself felt. The tendency had been to accept species as the results of acts of special creation, and hence to be well defined and immutable. Efforts to settle actual relationships between species gradually led to a reiteration of the question "What is a species?" But the theory of special creation and fixity of species was an insurmountable obstacle to progress. As Bentham puts the matter: "We were less authoritatively told that the resemblances of certain species were owing to their having been formed upon one plan variously modified. To the question why they were so modified, the ready answer was, such was the will of the Creator; and in order not to suppose that that will was influenced by mere caprice, it was suggested that the modifications were either to suit the plant to the circumstances it was placed in, or to remedy defects

in the original plan, or we were simply told that the subject was beyond our powers of comprehension."[1]

Though, as we shall see, Darwin presented us with the solution to these perplexities, the thoughts of many other writers before him had groped, though perhaps feebly, in the right direction. We can trace the recognition of the problem of the gradual transition from one species to another, rendering delimitation so difficult and uncertain, as far back as the time of Ray who states it in a remarkable passage in the preface to the *Historia;* it was present, too, to the mind of Linnæus who practically copied Ray when he said :[2] "Natura non facit saltus." But the first indication of a solution Darwin attributes to Wells in 1813 and 1818. Indeed, he gives him the credit of recognising the principle of natural selection,[3] though his application of it falls far short of its real extent, being confined indeed to the races of man. Another feature of the truth presented itself to Herbert in 1822 and was more fully stated by him in 1837 in a passage to which Darwin calls attention, and which we have already quoted (page 381). In 1826 Grant declared his belief that species are descended from other species; in 1831 Matthew gave the same view on the origin of species, Darwin says,[4] "as that propounded by Mr. Wallace and myself." As we have seen in an earlier chapter McGillivray in 1840 made similar suggestions. Opinion in Germany showed a trend in the same direction, though it never made itself very strongly felt. Sachs says,[5] speaking of Schleiden and Nägeli and the new morphologists, "they either inclined to entertain the idea of descent before the appearance of Darwin's great work, or gave a ready assent to the principle of the new doctrine. . . . Hofmeister's researches in morphology and embryology (1851) threw an entirely new light on the relations of affinity between the great groups in the vegetable kingdom, and were leading more and more to the view, that there must be some special peculiarity in the question of the constancy of organic forms. But the idea of evolution in the vegetable kingdom was brought more distinctly home to men's minds by palæontological researches. . . . Unger especially . . . after twenty years of preliminary study declared distinctly in 1852 that the immutability of species is an illusion, that the new species which have made their appearance in geological periods are organically connected, the younger

[1] *Brit. Ass. Report*, 1874, p. 31.
[2] *Phil. Bot.*, 77.
[3] *Origin of Species*, xv.
[4] *Loc. cit.*
[5] *History of Botany*, p. 183, English trans.

having arisen from the elder. . . . Nägeli wrote, 'External reasons . . . leave scarcely a doubt that species have proceeded one from another.'"

But all these stirrings of the mind shared by so many naturalists of high standing in many countries were only preparatory to the great independent generalisation of Darwin. As presented in the writings we have quoted small pieces of the solution can be seen, but the outlook is more nebulous and incomplete than well defined. It remained for Darwin by his marvellous grasp of the different features of the problem to set forth its solution with an approximation to completeness, and by years of patient experiment and research to establish it on a basis which commanded general acceptance.

Charles Darwin was born in the year 1800 and was educated for two years at the University of Edinburgh. He then removed to Christ's College, Cambridge, entering in the Lent term of 1828. His undergraduate career was not marked by any particular feature, save a growing taste for natural history which he developed under the influence of a strong personal friendship for Henslow, then Professor of Botany in the University. He went down from Cambridge in 1831, having taken the ordinary degree. The intimacy which he contracted with Henslow in all probability directed the course of his future life, for, at the professor's suggestion, he undertook the well-known voyage round the world in the "*Beagle*," the expedition being under the command of Captain Fitzroy. The "*Beagle*" sailed in October 1831, and returned in 1836. The change in his life which was thus produced, is described by his son in the following terms: "He left England untried and almost uneducated for science; he returned a successful collector, a practised and brilliant geologist, and with a wide knowledge of zoology gained at first hand in many parts of the world. And above all he came back full of the thoughts on evolution impressed on him by South American fossils, by Galapagos birds, and by the general knowledge of the complex interdependence of all living things gained in his wanderings, and thus it was that within a year of his return he could begin his first notebook on evolution."

After his return he abandoned travelling; he worked chiefly in London for two years, when in 1839 he married. After living three years longer in London he moved in 1842 to Down in Kent where he passed the remainder of his life, dying there in 1882.

Darwin's life was thus, apart from the voyage in the "*Beagle*," on

the whole an uneventful one so far as the outer world was concerned. It was given up to philosophical inquiry, based very largely on his own experiments; and it had the most far-reaching influence upon the progress of inquiry among the leading intellects of the century.

The observations that he made during the "*Beagle*" voyage, especially on the puzzling problems suggested by the facts of geographical distribution, led him to see that the views which he in common with most men of his youth had held on the question of species, and which were what we commonly understand as orthodox, were inadequate and irreconcilable with facts. His opinions gained strength as time went on; his mind was always speculative and with true courage he followed up the direction it tended to take; he was constantly thinking upon the causes of the wonderful variety of nature and of the means by which it had been secured, following up such questions into the minutiæ of structure and resemblance. The change of front began before the conclusion of his voyage, and as far back as 1837 the idea of evolution rather than acts of specific creation as the mode of the origin of species had seized hold of his imagination. In 1842 the speculations he had indulged in were cast by him into the form of notes, which Hooker says fully described the theory of the dependence of natural selection on the struggle for existence. In 1844 he enlarged these notes and from them drew up a sketch of his conclusions which comprised about 230 pages of manuscript. During the two years which intervened he had been strongly impressed by Malthus's *Essay on Population*, in which the subject of checks to numerical increase was discussed with considerable force. Lyell's writings, too, were not without influence on his thought. After critical scrutiny of the facts in the light of all the information he had accumulated, his philosophical caution and his reluctance to indulge in hasty generalisation induced him to put forward his views still in a very tentative manner, and in a letter to Hooker in the latter year he went no further than to say: "I am almost convinced . . . that species are not immutable." The slow progress of his thought is evidenced by another passage, in which he says: "When I was on board the '*Beagle*' I believed in the permanence of species, but vague doubts occasionally flitted across my mind. . . . In July 1837 I opened a notebook to record any facts which might bear upon the question, but I did not become convinced that species were mutable until I think two or three years had elapsed."

The facts that he had accumulated as to the geographical

distribution of species seem to have finally determined his conception of the theory, and to have furnished him with an irresistible argument for it.

The sketch made in 1844 which he showed to Sir Charles Lyell and to Dr. Hooker was practically the first appearance of the great work which, many years later, took the form of the *Origin of Species*.

The theory which Darwin propounded was at the outset based on the hypothesis that animals and plants vary continuously in a state of nature, their descendants differing slightly in many ways from their parents. Starting from this point he showed that more individuals of every species are born than can live, so that there is a struggle for existence among them, in which the better chance of surviving is possessed by the being which varies in a manner or direction profitable for itself, and which will thus be naturally selected. He claimed that from the strong principle of inheritance any selected variety will tend to propagate its new and modified form, the same struggle and success being, however, noticeable among its descendants. He omitted, he says, to consider sufficiently in his first presentation of the theory the tendency in organic beings descended from the same stock to diverge in character as they become modified. But he found his difficulty removed by the consideration that the modified offspring of all dominant and increasing forms tend to become adapted in the economy of nature to many places which are highly diversified. Thus he taught the inheritance of acquired characters. He did not believe in a reversion to the original type.

Darwin, however, admitted species as actually existing, and as well defined, and did not hold that variations are indefinite. Though he denied an independent act of creation for each species, he held that specific distinctions exist, and that the existence of species is prolonged. He said that natural selection is very slow in action, and at any given time only a few forms are under its influence, while its progress involves the continual supplanting and extinction of antecedent and intermediate gradations. He held that it is not reversible.

Applying the theory to considerations of affinity, he said that organs similar in appearance and function may have been separately and independently formed, and consequently their presence does not indicate affinity unless their structure is similar.

It is clear, therefore, that he considered that Lindley's views, based on physiological resemblances, were fallacious, and that structure based on descent is the key to affinity. Even modifications of

structure do not always mean adaptation to physiological function, for in many cases such modifications may be the direct result of the laws of variation and growth independently of any advantage accruing from them.

Darwin thus brought to light the true basis of classification, showing it to be descent and modification—that a true natural system must be of the nature of a genealogical tree, affinities being nearer or farther away according to the point from which the individuals or races branched off from the parent stem.

For many years after 1844, with infinite patience and perseverance, Darwin was engaged upon critical and experimental examination of the theory and upon accumulating all possible evidence that bore upon it. But somewhat suddenly, early in 1858 the same solution of the problem flashed independently upon the mind of another naturalist who, working far away in tropical forests, found himself face to face with the same questions, asking forcibly for an explanation. Alfred Russel Wallace was born in 1823 and after an uneventful youth threw himself at the age of twenty-one into the field of geographical exploration, gratifying thus an ardent zeal for natural history with which he was born. His earlier travels took him to the Amazon and to Rio Negro, a journey in which he had the companionship of Bates. After four years he returned to England, and in 1854 he entered upon those researches in the Malay Archipelago which added so greatly to his fame. Of the two works in which the records of his travels were given to the world, his *Narrative of Travels on the Amazon*, and his *Malay Archipelago*, the latter is very greatly the most noteworthy—indeed, it takes rank with Darwin's own *Voyage of the Beagle.* It was in the main during his Malayan expedition that the question of the origin of species occupied his thought. He was familiar with the published *Journal* of Darwin which had, indeed, inclined him towards a life of travel. Strangely, too, he was influenced by the same writers, particularly Lyell and Malthus. In 1858 he formed conclusions which were almost identical with those which had been and were then the occupation of Darwin's mind. In June of that year he wrote to Darwin from the Island of Celebes and asked his consideration of a sketch of a theory of natural selection which he had drawn up, and which proved to be almost identical with that which Darwin had made in 1844.

Had it not been for this extraordinary coincidence there is no doubt that Darwin's views would have waited still longer before publication. Indeed, there was at the moment a possibility that

they would never appear, for the older man with a wonderful generosity was at first inclined to waive any rights of priority which he possessed and to allow the theory to make its way into the world of science fathered by Wallace alone. It is well that reflection made him hesitate to adopt this course, for had he followed out his first thoughts the vast accumulation of facts which he had collected in so many years, and the records of the numerous experiments he had made might never have seen the light. Though Wallace's paper went to the point as clearly as did his own, it was no further advanced than Darwin's sketch of thirteen years earlier. Darwin with a certain shrinking from an aggressive line of action put himself in the hands of his friends Hooker and Lyell. Sir Joseph Hooker describes what the result of their intervention was in the following words: "After writing to Sir Charles Lyell Mr. Darwin informed me of Mr. Wallace's letter and its enclosure in a similar strain, only more explicitly announcing his resolve to abandon all claim for priority for his own sketch. I could not but protest against such a course, no doubt reminding him that I had read it, and that Sir Charles knew its contents some years before the arrival of Mr. Wallace's letter; and that our withholding our knowledge of its priority would be unjustifiable. I further suggested the simultaneous publication of the two, and offered—should he agree to such a compromise—to write to Mr. Wallace, fully informing him of the motives of the course adopted."

The course suggested by Sir Joseph Hooker was carried out, and both sketches were read together at a special meeting of the Linnean Society on July 1, 1858. Darwin's paper was "On the Tendency of Species to form Varieties; and on the Perpetuation of Varieties and Species by natural means of Selection"; Wallace's, "On the Tendency of Varieties to depart indefinitely from the Original Type."

The new views naturally excited immediate attention, and met with very different receptions in different quarters. The theologians were up in arms at once and bitter controversy ensued. But with the attitude of the scientific world we have more concern. There was not unnaturally at first a certain difference of opinion which in some quarters was almost embittered by a feeling of consternation at so formidable an attack on that dogma, the fixity or constancy of species, which had hitherto underlain all taxonomic proposals since the days of Linnæus. Bentham spoke of the old views as "long-cherished convictions, the result of much

labour and study." To Bentham particularly, the disclosure of Darwin's proposals partook of the nature of a shock. He had prepared a paper on the fixity of species which he intended to read before the Linnean Society at the same meeting in 1858. In a letter to Mr. Francis Darwin in 1883 he speaks of the experience he underwent on that evening. He says: "Most fortunately my paper had to give way to Mr. Darwin's, and when once that was read, I felt bound to withdraw mine for reconsideration. I began to feel doubt on the subject." The attitude that Bentham assumed was not one, however, of opposition; he felt that to his mind many questions were opened that needed careful examination—as he expressed himself elsewhere he felt that many important outworks remained contestable, and at the moment he did not feel willing to throw overboard his own convictions. This was, no doubt, the attitude of many of his school. Gradually, however, he accepted Darwin's position and readjusted the basis of his taxonomic views. In the letter already alluded to he says: "On the appearance of the *Origin of Species* I was forced, however reluctantly, to give up my long cherished convictions, the result of much labour and study, and I cancelled all that part of my paper which urged original fixity."

But on the other hand Darwin found cordial supporters, the chief amongst whom were Lyell and Hooker. The latter was one of the earliest and ultimately the most hearty advocates of the new position. He was no mere convert to Darwin's views; his own observations and reflections had led him far on the road to the acceptance of evolution before the appearance of the new theory. He approached it from a somewhat different standpoint, and his path only slowly converged towards Darwin's. He was led from the outset by his study of geographical distribution, which to him stood first. The conception of variation and descent were present to his mind, but they were subordinate to the problems in which he took so great an interest. By a somewhat different route, therefore, he came to similar conclusions. His intimate friendship with Darwin did not lead him to any hasty endorsement of all the details on which Darwin based his theory—rather he played the part of a candid critic and accepted nothing till he had thoroughly examined it, and it commended itself to his judgment. Though with him cordially as an evolutionist it was only with a certain slowness that he admitted the potency Darwin claimed for natural selection as the great instrument in bringing it about.

Hooker rendered Darwin great assistance on the botanical side

of his work by placing at his service the vast knowledge of detail which he possessed.

Hooker's reflections on the problems occupied him during the time antecedent to the publication of the *Origin of Species*. By the year 1858 he had become in comparatively close accord with Darwin, and when in December 1859 he published his *Introduction to the Australian Flora*, in its first part he gave full recognition to the truth of the modification of species through descent, and supported the doctrine by many original observations.

The attitude of Huxley was characteristic also. Though in his later years he gradually drifted away from what came to be called Darwinism, which must be distinguished from evolution, and in his old age practically threw it overboard he was in the early days equally outspoken. He said: "My reflection when I first made myself master of the central idea of the 'Origin' was 'How extremely stupid not to have thought of that.'" In America Asa Gray gradually became an enthusiastic supporter of the new ideas.

In Germany the views were received no less appreciatively, but they were examined very critically, and their bearing on current problems discussed, not without some bitterness. Sachs says that Darwin "showed that the constancy of species was no longer an open question. . . . The establishment of this truth was followed as a matter of course by the true conception of that which had hitherto been figuratively called affinity; the degrees of affinity expressed in the natural system indicated the different degrees of derivation of the varying progeny of common parents. Out of affinity taken in a figurative sense arose a real blood-relationship, and the Natural System became a table of the pedigree of the vegetable kingdom. . . . Darwin's theory has this special interest in the history of the science, that it established clearness in the place of obscurity, a scientific principle in place of a scholastic mode of thought in the domain of systematic botany and morphology. . . . It is quite certain that Darwin has not formed his theory in opposition to morphology and system, and drawn it from any hitherto unknown principles. On the contrary he has deduced his most important and most incontestible propositions directly from the facts of morphology and of the natural system as it had been developed up to his time. He is always pointing expressly to the fact that the Natural System . . . is not built upon the physiological but upon the morphological value of organs. . . . He clearly perceived the discordance

between systematic affinity and adaptation to conditions of life which De Candolle but imperfectly recognised. This clear perception was the one thing needed to mark the true character of the natural system, and to make the theory of descent the only possible explanation of it."

Sachs says further that Darwin "did actually gather from existing natural systems of plants and animals the rules by which systematists had worked unconsciously and never with a full recognition of them."

Darwin's own pronouncement on the influence of his theory on the question of classification is given with no less clearness. He says: "The Natural System is founded on descent with modification—community of descent is the hidden bond which Naturalists have been unconsciously seeking, and not some unknown plan of creation or the enunciation of general propositions, and the mere putting together and separating objects more or less alike. . . . The Natural System is genealogical in its arrangement like a pedigree; but the amount of modification which the different groups have undergone has to be expressed by ranking them under different, so-called, Genera, Sub-families, Families, Sections, Orders and Classes."

Wallace has recently explained with much lucidity the stages by which he reached the same conclusions. While studying the phenomena of the varieties occurring among wild animals and the question of the permanence of species, together with the tendency of any variety left to itself to return to the normal form of the parent species he came to regard life as a struggle for existence. He was much impressed by Malthus's writings on the positive checks to increase in man, and came soon to apply the principle of such checks to animated nature as a whole. Thence it was a short step to the idea of the survival of the fittest. Wallace saw, however, that with unchanging conditions there would be no necessary change of species. The last stage was supplied by Lyell's *Principles of Geology*, in which was a proof that the inorganic world has always been in a continual state of slow modification. Hence it follows that varieties must have become continuously adjusted to such changing conditions in order to survive. "The succession of fossil remains throughout the whole geological series of rocks is the record of this change; and it became easy to see that the extreme slowness of these changes was such as to allow ample opportunity for the continuous adjustment of the organic to the inorganic world, as well as of each

organism to every other organism in the same area, by the simple processes of 'variation and survival of the fittest.'"

The theory thus set out by Darwin and Wallace owed not a little of its success to the influence of Hooker. He was the first to accept it, and it had his advocacy always. The value Darwin attached to his adherence was indicated in a sentence in one of his letters to Wallace: "I look upon Hooker as by far the most capable judge in Europe." Lyell gave in his adhesion more slowly, but he was not very long before declaring himself on Darwin's side. The intemperate opposition made to his views by the clerical party in England failed to hinder their spreading—indeed, its very intemperance tended to turn thinking people towards their acceptance. A most notable conflict between the two schools of thought took place at the meeting of the British Association at Oxford in 1860, when the Bishop of Oxford attacked the Darwinian position with considerable acrimony, only to find himself quite overwhelmed by the masterly advocacy the evolutionary theory received at the hands of Huxley. The controversy for many years waxed warm, but gradually the new hypothesis became, at any rate in its main outlines, accepted throughout the scientific world. Further developments naturally followed, and many problems that had been hopeless puzzles were gradually elucidated. Particularly was this the case in the field of botanical geography; indeed, it may be taken as certain that the observations of geographical distribution made by so many taxonomists, themselves also explorers, notably by Robert Brown, Hooker, and Darwin himself, paved the way not only for the inception of the theory by Darwin, but also for its acceptance so rapidly by his contemporaries.

But there remains another side of Darwin's work which has had an influence on the progress of botanical research only second to that exerted by his *Origin of Species*. In a large measure the natural outcome of the latter almost at once revolutionised the methods and direction of botanical work, substituting finally a definite plan of investigation for what had been up to that time almost entirely empirical. Phylogeny, as a definite line of inquiry, pointed to the investigation of physiological problems; the inquirer saw before him living individuals engaged in the struggle for existence and the propagation of their kind, contending at once with one another and with their environment; almost for the first time he recognised *life* as the central point of interest, while details of structure acquired a new importance as they were in-

terpreted in the light of this inevitable contest and turmoil. The idea of the transmission of favourable variations to their offspring opened up a field of great importance, the possibility of the inheritance of acquired characters, a physiological hypothesis which was to become later the subject of critical scrutiny and experiment. Physiological need in the presence of environmental difficulties suggested processes of adaptation of the individual as well as of the race, and pointed to an effort of the living organism to assume or acquire peculiarities of form and structure harmonising with the nature of the life it had to lead.

Perhaps at the outset Darwin hardly realised how far his work was to lead him in that direction. Writing in 1876 he said: "In my opinion the greatest error I have committed has been not allowing sufficient weight to the direct action of the environment, *i.e.* food, climate, etc., independently of natural selection. When I wrote the *Origin*, and for some years afterwards, I could find little good evidence of the direct action of the environment; now there is a large body of evidence." At the same time we must remember that in 1844 he spoke of "species becoming exquisitely adapted to various ends."

When we turn to scrutinise the services Darwin rendered in the field of physiological inquiry, we find at the outset that, as a matter of fact, he had had little or no botanical training and did not consider himself at any time more than a tyro in the science. But he had a wonderful power of mastering the work of others and of building upon such foundations. This is clearly shown in his handling of the facts of geographical distribution or botanical geography. He had accumulated a vast mass of detail during his own travels, but he drew with consummate ease upon the stores of knowledge gained by the journeys of Banks, Hooker, and other explorers, making himself as well equipped as if he had accompanied them in their travels.

But the path of physiological research always attracted him, and after the publication of the *Origin* it seemed to dominate his thoughts. The time was ripe for such inquiries. But little had been done in this direction since the days of the activities of Robert Brown, and his work in the field was scarcely systematised. Valuable as were his contributions they were isolated, based on no definite plan and for the most part almost hidden in the details of taxonomic memoirs. The spirit of Hales and of Knight had in his later years disappeared and the record was almost blank. Darwin changed the face of things and physiological research

entered upon a period of renewed activity. Investigation ceased to be empirical and, at any rate in his hands, became dominated once more by *idea*. Under such auspices research was no longer an almost purposeless collection of new facts, but took the direction of definite lines of inquiry, aiming at the elucidation of natural phenomena.

This delimitation of new problems soon marked Darwin's own subsequent work. He saw that in the struggle for existence large physiological problems forced themselves to the front, and he turned to their elucidation with an "irresistible desire to understand the machinery of living things." His evolutionary and physiological work were consequently closely linked together. Especially was he drawn to the contemplation of the relations of the individual to its environment, problems which can be seen to be the basis of most of his physiological works. He wrote in 1862 that his leanings were more and more towards the direct action of physical conditions on the organism. As he felt that in the long run, great adaptations are reached through the action of Natural Selection, he aimed at elucidating their development through the mutual action and reaction of the organisms concerned and the environment in which they live. Here we have a leading idea which appears in his great works on the *Fertilisation of Orchids* and other flowers, in which he traversed ground that had been occupied by workers in the same field abroad. He went further, however, and inquired whether any particular individual had any power of reacting to changed conditions and of modifying either its behaviour or its structure as such changes are encountered. Is some form of sensitiveness and response to stimulation one of the factors in the individual upon which Natural Selection may work? Here we have almost the starting-point of a new physiology so far as plants are concerned—one challenging the dictum of Linnæus "Plantæ non sentiunt."

In this field of course he did not break altogether new ground. Knight's experiments on geotropic and heliotropic curvatures had dealt, with some minuteness, with particular phenomena of the kind, but he did not bring forward the idea of sensitiveness in connection with them, looking, like all the physiologists of his time, for a mechanical explanation. Even a hundred years earlier still Ray had attempted to explain heliotropic curvature, but his experiments were of the crudest, and, as was natural in a follower of Jung, he had not properly more than a mechanical explanation to advance. Von Mohl in 1827 had advanced the view of a par-

ticular form of sensitiveness in climbing plants. But Darwin went much further than any of his predecessors and claimed for plants the possession of such sensitiveness, and such application of it to subsequent movement as justify us in predicating in them some rudimentary form of a nervous system.

In the study of the phenomena characterising this new field of purposeful adaptation Darwin mainly occupied the years at Down after the *Origin* had seen the light. The first investigation that followed its appearance was the prolonged inquiry into a subject essentially cognate to it, the "Variation of Animals and Plants under domestication," the work for which was begun in 1860 and was published in 1868. This was largely in the nature of an extension of the *Origin of Species*, but still it led him in the direction of more exclusively botanical work, and brought forward the study of purpose in adaptation. We cannot but notice how the evolutionary and the physiological work of these later years were interwoven, for many of the botanical works seem to be partly of the type of monographs dealing with discussions, touched upon in the *Origin of Species*. The one great theme seems to have been always present in his mind, even when he was dealing more immediately with these other weighty problems.

The study of the pollination of flowers by the agency of insects had always interested him and he had published some observations on the process in the case of the garden bean in the *Gardener's Chronicle* in 1857 and 1858. In 1862 appeared that most fascinating book on the *Fertilisation of Orchids* in which the interdependence of flower and insect was fully discussed and illustrated. In 1864 his early work on the mechanisms of Climbing Plants was communicated to the Linnean Society, to reappear in book form eleven years later.

In 1875 he published the volume on Insectivorous Plants, which was followed by the effects of Cross- and Self-fertilisation of Flowers in 1876 and Heterostyled Plants in 1877. The last volume of the series was written in association with his son Francis, and appeared in 1880 under the title of *The Power of Movement in Plants*. This was in many respects the most noteworthy of all his botanical work; in it he promulgated the theory that all the so-called movements are modifications of one fundamental phenomenon of growth, *circumnutation*, and that they are essentially responses to stimulation, affording evidence of a high degree of sensitivity.

These writings, especially the last, are monuments of patient assiduity, of keen insight and ready perception, and of a high

degree of skill in devising and carrying out experimental research. They show the mind of a man absolutely devoid of personal prejudice or predilection, bent on bestowing as thorough criticism upon his own methods and results as upon those of a rival investigator. The reader is impressed at once with the certainty that his object was solely to ascertain truth and that there was no turning aside to establish doubtful hypotheses. In these books he opened the way for the recognition of sensitivity as an important factor in the individual life, and showed how essential a part it may play in the struggle for existence, being indeed one of the factors undergoing variation on which Natural Selection may work.

Apart from the actual work which Darwin carried out, his writings from the *Origin of Species* onwards gave a great stimulus to the study of Phytodynamics in general, both in England and abroad. The idea of action and reaction between the organism and its environment became the basis of investigation in much detail, apart from its influence on the broader theme, and as a consequence researches became more numerous, and the conception of nervous change obtained a wider acceptance. The point of view, too, changed rapidly; in the consideration of the behaviour of plants, the readily observable "movement" was seen to be the result of some internal change, and the perception of the change rather than the consequent alteration of position or disturbance of growth attracted the attention of the observer, and was seen to be the factor calling for explanation. Stimulation, in fact, came to be recognised; the old idea of sensation as an endowment of vegetable substance, held by the older writers in a mistaken form, and subsequently denied by the leading men from Linnæus downwards, gradually grew into favour, and became established on a firm basis. Movement, instead of being regarded as a direct and mechanical result of purely physical influences, came to be realised as a vital phenomenon, the result of a response made by a sensitive organism to some modification of its surroundings. The idea, in fact, of *purpose* in the life of the plant became established.

The work of Darwin thus prepared the way for the reception in this country of the celebrated memoirs of Frank, Wiesner, and other contemporary writers abroad, who did so much before the end of the century to elucidate more fully similar phenomena. It is not a little to be regretted that in Britain he has had so far so few followers. He held the field by himself for twenty years, but with the exception of his own son, he can hardly be said to have had any successor.

CHAPTER XLVI

SIR JOSEPH DALTON HOOKER AND HIS WORK

BESIDES Darwin there were two other figures who stood out conspicuously during this period—Bentham and Hooker—men of the foremost rank as taxonomists, one of whom played a part only second to that of Darwin in the establishment of the new movement. They were men of such eminence and workers whose labours extended over so long a period that it is difficult to say with which part of the century they should be most suitably associated. But the story of the change in opinion as to the fixity of species brought about by the appearance of Darwin's book would be incomplete without the consideration of the part played by Hooker in its dissemination, and it seems therefore appropriate to pass at once to the career of one who was as pre-eminent in the latter half of the nineteenth century as Robert Brown had been in the earlier years, Joseph Dalton Hooker, distinguished alike as geographer and philosopher, as well as a great leader in taxonomy, and a highly successful administrator.

He was the younger son of Sir William Jackson Hooker, and was born in 1817, during his father's residence in Suffolk. The removal to Glasgow, which took place in 1819, led to his education at that city, first in the High School and later at the University, where he graduated as M.D. in his twenty-second year.

Born of such a parent, and brought up in an atmosphere charged with the scientific spirit, it is not to be wondered at that from his early years he was imbued with a love for botany, and with a passion for exploration and research. Like Banks and Robert Brown his early aspirations stretched out in the direction of foreign travel, and he cherished the ambition to add his name to the list of distinguished explorers, who had done, and were doing, so much to make known the surface of the globe in the regions that still remained unsurveyed. Unlike most of these travellers, however, he had a more definite aim than they: he was inclined to be no mere narrator of facts, but to bend himself to the great problems of the distribution of living forms over the surface of the globe, and to aid in determining the causes of the variety of

flora and fauna, which characterised its different regions. He started his life work consequently with a predisposition that led him steadily, if slowly, to a conception of species which converged towards, and ultimately blended with, the views at which Darwin arrived by a somewhat different path.

In studying Hooker's life it is almost necessary, certainly always advantageous, to bear in mind this point of view. To this great end—the solution of the problems of geographical distribution—most of his work seems to point. Though he handled many problems which seem at first not to have much to do with this greater one, the same line of thought, the same definite aim, can ultimately be seen to affect his method of examination of them all.

His association with Darwin began in the same year as his graduation, 1839, some three years after the return of the "*Beagle.*" Darwin published his *Journal of Researches* in that year, and a copy of them fell into the hands of Hooker, on whom it made a deep impression, stimulating him to immediate effort to begin to tread the path he had sketched out already for himself. He made Darwin's personal acquaintance in the same year, an acquaintance that was to develop into one of the warmest and one of the most eventful friendships of the century.

Stimulated thus, both by personal predilection and by ardent emulation, Hooker volunteered to accompany Sir James Ross in the celebrated Antarctic expedition which left England in 1839. His offer was accepted, and he was given the appointment or commission of assistant surgeon on board the "*Erebus.*" Though such was his technical rank, he was really the naturalist of the expedition. The voyage lasted for three years, the vessels, the "*Erebus*" and the "*Terror,*" visiting New Zealand, Australia, Kerguelen Land, Terra-del-Fuego, and the Falkland Islands. Three months were spent in Tasmania, three more in New Zealand, and finally five more in the Falkland Islands, and the results, from a botanical point of view, were of enormous importance, on account of the mass of material collected and brought home.

The publication of part of the results, dealing with the *Flora of the Antarctic Islands*, was his first charge on arriving home. He dealt with all the material that had been received from other travellers as well as with his own collections, and while he presented his results as a taxonomist he kept steadily in mind the problems of the origination of the flora and of its geographical distribution. To the discovery of the laws regulating these phenomena he had always been attached, and this, his first personal experience of

exploration, strengthened his purpose, which became, perhaps somewhat at the instance of Darwin, his chief aim in his scientific career.

The *Flora of the Antarctic Islands* appeared in two volumes in 1844 and 1847, prefaced by a fairly graphic account of the incidents of the whole voyage, and it marked out the author as one of the first taxonomists of the time. The grip of the subject it displayed, together with its breadth of view, was a foretaste of what was to come. Not that it so much solved as stated the great problems of distribution which were to occupy its author during a great part of a long life.

His return did not take place until after the changes at Kew, in consequence of which his father had become Director of the Gardens, and had removed from Glasgow. He did not at once join him, but took up his residence at Edinburgh, where for the last two years of the life of Professor Graham he acted as his assistant. On Graham's death in 1845 he was a candidate for the succession to the Chair of Botany in the University, but was not chosen. In 1846 he was appointed to succeed Henfrey on the Geological Survey, and he was attached to his first post there till 1847. He took the opportunity of making a study of Palæobotany as far as it was then known, and contributed later several papers to the literature of the subject.

In addition to his work in this field he made a careful study of the flora of the Galapagos Islands, a subject which had presented a great fascination also to Darwin. The character of the flora and the isolation of the Islands, and particularly the close resemblance, falling somewhat short of identity, of species in the several islands offered strange and difficult problems for solution. At that time migration of fruits, etc., over long tracts of sea had not been demonstrated with the clearness which afterwards became apparent, while descent of modifications, the results of variation, had not been promulgated. The whole question presented many points which appealed to Hooker, and he published two memoirs on them in the Linnean Society's *Transactions* in 1847.

It was while Hooker was thus occupied that Darwin made him acquainted with his views on the origin of species, and showed him the sketch of his theory to which allusion has already been made. The first communication was made in January 1844, in a letter which contained the following passage:—"I am almost convinced that species are not (it is like confessing a murder) immutable; I think I have found (here's presumption!) the simple way by which species become exquisitely adapted to various ends."

But Hooker was soon to resume his work of botanical exploration. A movement was set on foot partly in England and partly in India, for the investigation of the natural features of certain regions of the Himalayas, and finally a Government mission was appointed, and Hooker was placed in charge of it. As a result he retired from the Geological Survey in 1847, and entered upon those Indian travels which led him to the incomparable knowledge of the Indian Flora for which he was so celebrated. The first expedition was to North-Eastern India, which was then unexplored; he worked through the plain of the Ganges and Behan, and thence went to the Himalayas and Sikkim, studying both the geography and botany of that vast region, all the while accumulating more data for use in discussing the problems of distribution. While in that region he surveyed the passes leading into Tibet, and accumulated data which were later of some political importance. Nor did geological investigations escape him, for he made observations of considerable value on the physical configuration of the district. Late in 1848 he went, with the encouragement of Jung Bahadur, to Eastern Nepal, the only botanist who ever travelled there. After working alone till 1849 he was joined by Dr. Campbell the Governor-General's Agent, who was at the time the Superintendent of Darjeeling, and who had had some experience of similar work in the Himalayas. While travelling in Sikkim they had the infelicitous experience of imprisonment by the Rajah in consequence of some dispute between the latter and the Indian Government, and were detained in durance till the end of the year.

A few months after his release Hooker was joined by his friend Dr. Thomas Thomson, who had been engaged in botanical work in the Western Himalayas and in Tibet. Starting in 1850 they carried out an expedition to Eastern Bengal, Chittagong, and the Khasia Hills, which lasted two years, when they returned to England together.

Before dealing with the results of these arduous labours it is interesting to notice that it is to these journeys that Kew is indebted for its splendid Rhododendrons, which Sir W. J. Hooker succeeded in getting into cultivation from material sent home by his son.

The two travellers amassed something like 7000 species of plants in these explorations which called for immediate disposal. Many duplicates were distributed to various herbaria, but the great bulk was housed at Kew. The next few years were spent in sorting and naming them, a work in which Hooker had Thom-

son's assistance till 1854, when the latter returned to India to take up the Superintendence of the Calcutta Botanic Garden. Hooker finished the task, and in addition wrote the *Himalayan Journals*, which appeared in 1854.

Hooker and Thomson intended that their work should appear in the form of a *Flora Indica*, and they set out to prepare it, but their plans were laid on too ambitious a scale. The work was broken off abruptly at the end of the first volume, and was not resumed for many years. Had the original idea been completed the work would have reached nearly 12,000 pages, an impossible task at any rate for any publisher. The material was housed at Kew, and together with many large subsequent additions formed the basis of Hooker's *Flora of British India*, which occupied him for many years later in life.

This introductory volume, however, was in some respects a noteworthy production, including, as it did, a sketch of the physical features and vegetation of the Provinces of India, which aided materially to the scientific knowledge of that country. The introductory essay, too, is of great interest, for it contains a statement of his opinion of the part played in nature by the struggle for existence amongst plants, and it shows a certain approximation to Darwin's position, which from the intimacy between them was within his knowledge.

During this period, too, Hooker found time to go back to his early work in the "*Erebus*" and "*Terror*" expedition, and in 1853 the second part appeared, again in two volumes, dealing now with the Flora of New Zealand.

In 1855 Hooker was associated with his father at Kew, the office of Assistant Director being created for him, a step rendered necessary by the enormous strain which the development of the Gardens and the administration of what was practically a Government department was producing on the Director. Notwithstanding, however, the pressure of the consequent official work, the detailed examination and publication of his vast masses of material received assiduous attention. The appointment, nevertheless, pointing as it did to the prospect of his succeeding his father at some date possibly not so very distant, had its inevitable effect of insensibly drawing him to some extent away from pure science and binding him to the details of administration. Indeed, only four years afterwards he considered himself as standing on one side in the great controversy that was then agitating the world of biology.

Still before even such slight withdrawal as took place Hooker effected much. During the early years of his association with Kew he published the third part of the results of the Antarctic Expedition, the *Flora of Tasmania.* This was the most remarkable of all, for he took the opportunity to contribute to the first volume an introductory essay on "The Flora of Austràlia; its origin, affinities, and distribution." It appeared in 1859, and proved to be a most remarkable contribution to the subject of Geographical Distribution, and to contain the results of his speculations upon questions of the variation of species and its bearings upon evolution. It contained also an analysis of the Australian Flora, which showed the hand of a master, and which needed no modification in days long subsequent. Of this essay Darwin wrote: "To my judgment it is by far the grandest and most interesting essay on subjects of the nature discussed I have ever read."

Of the part played by Hooker at the critical juncture when the appearance of Wallace's paper forced Darwin's hand, and of the skill with which he secured the publication of those results which took their final form in the *Origin of Species*, we have already spoken. Had Darwin's first leanings been allowed to prevail much of Hooker's own work might seriously have suffered. The intimacy of the two was so close, and their convergence of their ideas at this period was so clear, that Hooker must be classed as second only to Darwin in the formulation of the theory.

During the early years of Hooker's work at Kew he felt very deeply the want of adequate authority for the delimitation of genera which proved a great obstacle to the progress of dealing with the great accumulation of plants at the Herbarium there, and contemplated taking up the task of an adequate pronouncement upon them. Similar ideas were working in the mind of Bentham, who was carrying out his own researches there. Learning what each was proposing they agreed to collaborate in the production of a new *Genera Plantarum*, a work on which they spent many years of laborious effort. Their association for the purpose seems to have begun in 1857, for there is in Bentham's diary for February 24 of that year a note, "writing on the principle of genera for J.D.H." The project took shape gradually but slowly, for in October 1859 he wrote of himself as "sketching out plan for *Genera Plantarum* with J.D.H." To the fuller consideration of this monumental work a subsequent section must be devoted. It was an enterprise marking Hooker's Assistant-Directorship.

In 1860 Hooker was invited by Captain Washington, Hydro-

grapher to the Royal Navy, to accompany a scientific expedition to Syria and Palestine, and he undertook especially the exploration of the celebrated Cedar Grove of Lebanon, of which little then was definitely known. Among the party was Daniel Hanbury, a celebrated pharmacist, and an intimate friend of Hooker. Hooker's interest in the expedition centred principally in the problems it afforded in connection with the distribution of species. On his return he published a memoir on the Cedars in the *Natural History Review*.

After his return to Kew he was occupied for some years with the examination of important collections of plants from various regions of the earth, which were continually being sent there by different travellers, and also with the publication of part of the enormous mass of material which he had himself collected. Besides all this his contributions to the *Genera* were continually receiving his attention, so that we may well conceive his industry was indefatigable.

In 1862 appeared a further contribution to the subject of geographical distribution in the shape of his remarkable *Essay on the Distribution of Arctic Plants*, in which he examined the Arctic Flora as he had the Antarctic in his writings of a few years before.

In 1865, full of years and honours, Sir W. J. Hooker passed away, leaving to his successor a task of the greatest magnitude in the development of the Gardens which he had created, and the consolidation of the work which he had commenced. Of the way in which Dr. Hooker carried out his father's plans, and how he made Kew the magnificent institution the end of the century saw it, much must be said, but the narrative must be left for a subsequent section. Twenty years of earnest labour, combined with a genius for administration, left an indelible mark on Kew.

With the assumption of the honourable position of Director of the Gardens, to which he naturally succeeded, Hooker took a more prominent part in the public life of the time. He had been elected a Fellow of the Royal Society in 1847, and, after sitting on the Council for seventeen years, he became President in 1873. He occupied the chair for five years. He was President of the British Association at the meeting at Norwich in 1868, of its Biological Section at Belfast in 1874, and of its Geographical Section at the Anniversary meeting at York in 1881. Academic honours were freely accorded to him; Oxford made him honorary D.C.L., Cambridge, Edinburgh, Dublin, and Glasgow all gave him their honorary

LL.D. He was made Examiner to the University of London for two periods of five years each. The Government made him C.B. in 1869, K.C.S.I. in 1877, and G.C.S.I. in 1897, while after the end of the century, in 1907, he received the Order of Merit. European appreciation of his work was shown by his being made a Corresponding Member of the Institute of France and of nearly all the Continental Academies.

But the responsibilities and administrative cares of Kew did not take from Hooker his old attachment to travel, nor his interest in the problems which his journeys brought before him. Ever since his Syrian expedition he had been attracted by the features of geographical distribution which are presented by the Atlas Mountains, and he had long desired to explore their vegetation and to determine whether any connecting links exist there between the Mediterranean regions and the flora of the Canary Islands. At last an opportunity offered, and in 1871 he formed a party with two friends, Ball and Maw, to make an expedition to Morocco and thence to the Atlas. Some important results were obtained, and much information gained on the problems Hooker had at heart. On his return the results were in the main committed to Ball, who published them in 1878.

Yet once again did the veteran botanist, now at the age of sixty, undertake a similar tour, this time at the invitation of the United States Geologist in charge of the United States Geological and Geographical Survey. Together with several other ardent scientific workers, including Professor Asa Gray, Hooker visited the Rocky Mountains of Colorado and Utah with a two-fold object—to contribute to the knowledge of the botany of these States, and to examine the affinities of the North American Flora, so as to determine, if possible, whether the relations of that Continent with Asia are more marked on the Pacific or the Atlantic side, the latter being the phase of the work to which Hooker more particularly applied himself. To the solution of this problem he contributed some very important data, which formed the basis of a report to the United States Government in 1881. It would be out of place here, however, to discuss these explorations and their results at any length.

This was the last extended trip in which Hooker took part. After his return he devoted his life to the enormous task of completing the various works he had begun, and bringing his results into form for publication, incidentally dealing with such matters as the *Genera Plantarum*, the editing of the *Botanical Magazine*

and other literary work, besides for many years longer being responsible for the administration of Kew.

Hooker retired from the Directorship of Kew in 1885, and went to live at Sunningdale in Berkshire. For many years he continued, however, to work at Kew, where he occupied himself in the main with the Indian Flora. The *Genera Plantarum* had been finished in 1883, and Bentham had died soon after. The *Flora of India* had received much attention even while he was busiest in the affairs of the Directorship. The first abortive attempt made by him and his colleague Thomson had produced only a single volume. Later, indeed after nearly twenty years, Hooker took it up again and, planning it on a more modest scale, produced four volumes prior to relinquishing office. From 1885 to 1897 he was engaged on the remaining three volumes, aided by a staff of collaborators, whose work received his personal supervision. This memorable work deals with no less than 16,000 species of plants, and contains in all some 6000 pages of letterpress.

Before his retirement from Kew another almost monumental enterprise was set on foot, which had been originally suggested by Darwin, a scheme which culminated in a work worthy to be set beside even the *Genera Plantarum*. As we have noticed continually in these pages, the question of the synonyms of the plants of various writers had never been satisfactorily dealt with, and as time went on almost inextricable confusion had resulted. Darwin himself had experienced extreme difficulty in the accurate naming of his plants. He proposed to Hooker that a new work should be prepared which should provide an authoritative list of names that had been used by different writers; that the author of each and its original place of publication should be recorded, and that the priority of different names should be determined. Darwin undertook to be at the expense of the production. The idea was favourably considered by Hooker, who made himself responsible for the critical supervision of the whole publication. The details of the task were entrusted to Daydon Jackson, and occupied him and a staff of helpers for several years, appearing between 1892 and 1895 under the title of the *Index Kewensis*. Hooker read and carefully criticised all the proofs. The magnitude of the work can be realised when it is known that the *Index* consists of four quarto volumes, containing in all 2500 pages, each page of three columns, and each column dealing with about 50 names. Not less than 375,000 names are dealt with, the plants being

arranged on the lines of the *Genera Plantarum*. If it stood alone its services to botany could hardly be over-estimated.

The love of travel which Hooker possessed, even after he was no longer able to indulge it, found a new expression in the early nineties, by his undertaking to edit Sir Joseph Banks's Journal of Cook's first voyage round the world, to which we have alluded in its place. Hooker was not able to refer to the original journal, which was unfortunately lost for many years, but a transcript was in the British Museum, and this formed the basis of his work, which was published in 1896.

The end of the century found the veteran botanist still occupied with botanical studies. After the lamented death of Trimen, Hooker took in hand the task of completing the *Flora of Ceylon*, and he issued the remaining volumes in 1898 and 1900. The last one, indeed, was mainly his own work, for Trimen had hardly touched the materials.

This work taken in conjunction with the *Indian Flora* enabled Hooker to write the masterly "Sketch of the Vegetation of the Indian Empire," which appeared in the *Imperial Gazetteer of India* early in the next century.

Hooker's work thus was coterminous with almost the whole of the nineteenth century. After its close he could not be idle, and literary efforts were put forth during the next ten years. But it may well be held that his botanical work was not so much a feature of these years. It is with the nineteenth century that his name will be associated. He passed away at his residence at Sunningdale on December 10, 1911.

Hooker's scientific eminence was recognised as far back as 1854 by the presentation of a Royal Medal by the Royal Society, and was emphasised by the award of the Copley Medal in 1887, and the Darwin Medal in 1892, both by the same institution. He received from the Linnean Society the Linnean Medal in 1888, another, specially struck, in 1898, and the Darwin-Wallace Medal in 1908; on his 90th birthday in 1907 he received the Order of Merit. In the same year the Swedish Academy awarded him the medal struck in commemoration of the 200th anniversary of the birth of Linnæus. He received the Order of the Polar Star from the King of Sweden, and the Prussian "Pour le Mérite" with the King's express approval.

To deal with Hooker's writings in anything like full detail would be an almost impossible task. They began in 1837, when he contributed to his father's *Icones Plantarum* a description of

three new Indian Mosses. They extend beyond the end of the century.

While engaged in the duties of the Geological Survey he wrote several papers on the Cryptogams of the Antarctic region, from which he had recently returned. Besides the first part of his great Antarctic work, the first two volumes of which were completed by 1847, he wrote in that year a contribution to Sir W. J. Hooker's *Flora of the Niger*, in collaboration with Bentham, the first literary association of the two men.

During this period official publication of certain palæophytological work was part of his duty. He made some important investigations on *Stigmaria*, the root of certain of the Coal Measure Lycopods, and showed that the rootlets drew their vascular supply from the main axis. His researches into the structure of *Lepidostrobus*, besides throwing much light upon its morphology and anatomy, discovered the existence of its spores in the fossil specimen. It may almost be said that he gave us our first clear understanding of both these forms. He wrote, too, a very remarkable paper on *Trigonocarpon*, which he was the first to prove to be a type of seed, and he indicated an affinity between this plant and certain of the Gymnosperms, in which, though ahead of his time, subsequent researches showed him to be absolutely accurate.

But Hooker's duties soon called him from the field of palæophytology, and this was his last contribution to the subject. His writings showed him, however, to have been able to take a leading place among palæobotanists had circumstances led him that way; he manifested a truly philosophic spirit combined with a rigid adherence to accuracy in examination and determination of structural detail.

The year 1853 saw the appearance of the second part of the work of the Antarctic expedition, the *Flora Novæ Zealandiæ*, just after his return from India. The *Flora Indica*, unhappily confined to a single volume, appeared in 1854. In connection with this may be mentioned the preparation of two sumptuous folio volumes, the *Rhododendrons of the Sikkim Himalayas*, edited by his father, and the *Illustrations of Himalayan Plants*, under his own editorship.

The third part of the Antarctic work was published in 1860, under the title of *Flora Tasmaniæ*. It appeared at the moment when Darwinism and evolution were in the air, and it is not surprising that in it were discussed many problems of distribution

regarded from the new outlook. But a fuller consideration of Hooker's botanico-geographical work will occupy us later.

The period of his Assistant-Directorship of Kew (1855-65) saw great activity in his contributions to literature. In 1862 and 1864 he dealt with important collections of plants from Fernando Po and from the Cameroons, which followed on the classic essay on the distribution of Arctic Plants that appeared in 1861. His views on geographical distribution found further expression in a paper on Insular Floras, read to the British Association at its Norwich meeting.

In 1862 and 1863 appeared some of the fruits of his Syrian tour in a paper on the Cedars of Lebanon, Taurus, Algeria, and India, and in a sketch of the botany of Syria and Palestine, which he contributed to Smith's *Bible Dictionary*.

In 1868 and 1871 he published the two volumes of the *Flora of Tropical Africa*, seven personal contributions to the knowledge of which had appeared from his pen between 1847 and 1865.

The versatility of Hooker's mind was illustrated by some memoirs which he wrote about this period on morphological subjects. Like Robert Brown he was not merely a systematist, as his work on fossils already alluded to has made clear. He was like Robert Brown, ever alert to see the problems which taxonomic studies brought before him. The first of these morphological studies was a series of two memoirs on the Balanophoreæ, a group of reduced forms which have adopted a parasitic habit of life. In the course of these studies he dealt with the homologies of the pistillate flower, which has suffered greatly from abortion consequent upon its parasitism. Later he investigated the peculiarities of the Nepenthaceæ, curious pitcher plants which have developed the power of capturing and digesting insects. He carefully worked out the morphology of the pitchers, which he determined to be expansions of apical leaf-glands, and made some researches into the phenomena of the digestive processes which take place in them. This was his only research into problems of vegetable physiology.

Perhaps his most notable, certainly his most famous, research in morphology was his investigation of that strange South African plant *Welwitschia*, or *Tumboa*, a huge root-like body buried nearly to its apex in the sand, and bearing only a single pair of enormously long ragged strap-shaped leaves. This paper may well serve as a model for workers of to-day. It received the highest commendation of the leading botanists of the time, Asa Gray saying of it that it was "unrivalled among botanical monographs

of the kind for perfection of illustration, elucidation of structure, and insight into affinities."

The most important event that characterised these years was the commencement of the collaboration between himself and Bentham, which led to the preparation of the *Genera Plantarum*, the detailed consideration of which will occupy us in a subsequent chapter. Its position in point of time among his other literary labours calls for a brief allusion to it here. The completion of the first volume coincided in time with his succession to the Directorship of the Kew Gardens.

After his assumption of the charge of this great institution, when one might have thought the pressure of official duties alone would be almost too great to bear, we can only be astonished at the magnitude of the literary work which he accomplished. While we bear in mind that till 1883 he was occupied with the *Genera Plantarum*, we find that in 1870 he produced his *Students' Flora*, and in 1873 he rearranged the Natural families for the English version of the great treatise of Le Maout and Decaisne. In addition to all this he was still engaged with his own *magnum opus*, the *Flora of British India*, perhaps the most exacting as it was the most prolonged task of all. He published a catalogue in 1865, and another in 1870, which opened the way for a complete Flora on the lines adopted at Kew for the various Colonies. He began to write the latter in 1870, and it was only about half finished when he retired from Kew in 1885. Afterwards it became his principal occupation till he concluded it in 1897. From 1879 to 1883 he had some assistance in the work from C. Baron Clarke, the great Indian botanist and collector, whose specimens have enriched the Indian collections at Kew.

Besides these labours he found time in 1887 to revise the 5th edition of Bentham's *Handbook of the British Flora*, making it one of the most useful elementary guides to field botany of the time. He supervised the preparation of subsequent editions of this volume up to 1906.

Other literary work of rather different character made further calls upon his time and energy. He continued to edit the *Botanical Magazine* till 1902, and the *Icones Plantarum* till 1889.

But in forming an adequate estimate of Hooker's position as a man of science, it is not sufficient to take account only of his labours in the literature of taxonomy, nor to think of him as systematist and administrator. Early in life he had laid down for himself another line which he placed before himself to follow

through all his other activities. From the time when he engaged in Antarctic exploration his thoughts were led to the problems of geographical distribution, and he never lost sight of this goal, and largely in consequence of following it he reached those philosophical conclusions on the great problems of species in which he found himself so closely allied to the views of Darwin. In the course of his explorations of various regions of the world's surface he was always pursuing his aim of ascertaining the conditions that had led to the flora which he found, and if he did not solve his problems on the spot he accumulated large stores of data to serve for future examination. In this way his botanical investigations proper were in some sense subordinate to his life-long object, and he may be said in consequence to have founded the science of geographical botany. He had no predecessor but Alphonse de Candolle, who had worked on somewhat different lines and with a less comprehensive accumulation of facts. Till Hooker's time a flora was largely only a compilation of facts, and in a sense empirical—no consideration was given to the principles underlying its composition nor to the distribution of the species of which it consisted.

Though Hooker set himself to remedy this he was no hasty generaliser. His reasoning was always based upon a large accumulation of facts, and his conclusions were well reasoned and consequently weighty.

Several of his essays, as we have noticed in passing, were specially directed to the problems of distribution, as the facts of his explorations pointed to the questions raised and their solution.

Some of his conclusions were of vast importance, and threw a flood of light upon perplexing questions, based on the appearance of particular types in certain habitats. He was no believer in the idea of multiple creations, but looked for reasons for their occurrence in some method of migration. His views on the migration of the Scandinavian types across large areas into tropical regions have obtained general acceptance and certainly explain many anomalous occurrences. He said: "When I take a comprehensive view of the vegetation of the old world, I am struck with the appearance it presents of there being a continuous current of vegetation . . . from Scandinavia to Tasmania; along, in short, the whole extent of that arc of the terrestrial sphere which presents the greatest continuity of land. In the first place Scandinavian genera, and even species, reappear everywhere from Lapland and Iceland to the tops of the Tasmanian Alps. . . . They abound on the Alps and Pyrenees, pass on to the Caucasus and Himalaya, thence

they extend along the Khasia Mountains, and those of the peninsula of India to those of Ceylon and the Malayan Archipelago, and after a hiatus of 30° they appear on the Alps of New South Wales and the Antarctic Islands, many of the species remaining unchanged throughout!"[1] No doubt this aggressive character of the Scandinavian flora has materially contributed to the character of the vegetation of the warmer zones.

But though Hooker attached so much importance to migration he demanded for it continuous land areas. In his investigations on the Atlas Flora he attributed the presence of the Abyssinian types on the mountains of the Atlas and of the Cameroons to such a wandering, with a failure to survive on the lower lands between. He applied this view also to the Antarctic islands, suggesting that the identity of species existing in these isolated areas could be explained on the hypothesis of submerged land that had once connected them. He was, in this hypothesis of submerged land connections, a follower of Forbes and Lyell in their speculations as to continents once continuous, becoming dissevered by geological action. Consequently he took different views from Darwin as to the possibilities lying in migration across long tracts of sea.

The development of his views on the methods of dispersion and the building up of floras went on side by side with the maturing of his views on evolution. At first a believer in the fixity of species the new point of view gradually impressed him, and his close intimacy and friendship with Darwin was of the greatest advantage to both. It was, however, by a somewhat different path from that of Darwin that Hooker reached his conclusions.

Enough perhaps has been said to indicate the far-reaching extent of Hooker's work and the value of his researches to all interested in the fields of geographical and systematic botany. No one either before him or during his career ever exercised so wide an influence as he did—no one by his personal efforts carried either subject so far. He was for years the most prominent figure in the English botanical world. Even in directions which he did not make especially his own he commanded the admiration of all his contemporaries.

He was as eminent a philosopher as Darwin, and had as broad a view on the great questions that eventually took the form of the evolutionary theory. There is no doubt that he did more than any other man to establish the new views after their first promulgation. We have seen that but for him it is by no means certain

[1] "Introductory Essay on the Flora of Australia."

whether Darwin's work would have seen the light. A careful perusal of Hooker's writings shows that similar speculations had been for a long time floating in his own brain, though at that moment, in 1858, he was not prepared to formulate them. But we have seen that the ideas were there, and that they became gradually clearer till the pronouncement was as emphatic as Darwin's own. Of the essays in which Hooker put them forward Asa Gray said: "they are among the earliest and most notable contributions to this part of our science. They are endeavours to test the practical value in systematic botany of now familiar theoretical considerations, the influence of which was felt and the importance dimly divined in advance of their full development by Mr. Darwin."

While Hooker was possessed of the importance of the old systematic methods he realised their true development, extended them, and gave them elasticity. By showing that there is a great problem underlying the question of the mutual relationships of plants, and pointing out the paths to its solution he rendered an inestimable service to botany. Through the study of geographical distribution he discovered a path which led to the great conclusion. His wide knowledge and his keen insight enabled him to put it before the next generation as well from the geographical as the botanical point of view. He set to succeeding generations the inimitable method he possessed of the appropriate treatment of controversial subjects, combining the boldness of a master mind with the severe and critical examination of their data emanating from robust judgment and careful observance of all the facts.

CHAPTER XLVII

KEW UNDER SIR JOSEPH D. HOOKER

THE great work Sir W. J. Hooker had inaugurated at Kew, and had pursued with so much energy till his death, fell into the able hands of his son, Dr. J. D. Hooker, the leading incidents in whose career have already come under review. He succeeded to the Directorship of the Gardens in 1865.

One of his earliest acts was the rearrangement and re-naming of the whole of the Palm collection. He also at the outset gave considerable attention to the Arboretum, setting apart an annual sum of money for this purpose. In 1867 a severe winter destroyed many of the oldest trees in the Gardens, together with almost all the tender pines and cypresses and quite half the shrubs. The most denuded parts of the Gardens were replanted and the old wall widened and improved. In his Report of 1869 Dr. Hooker said: "As regards the general condition of the old forest features of the pleasure grounds, nothing favourable can be said. The beeches are rapidly dying through age, exhausted soil, disease, and fungi, and the elms and cedars through decay and exposure to the winds. Meanwhile, every effort must be made to plant open spaces on their outskirts and among them." A grass avenue, 250 yards long and 18 yards broad, was laid down from the south end of the Temperate House to the western approach to the Pagoda, through the collection of Rosaceous and other plants, and curious species of Hawthorn, *Pyrus*, etc., were arranged in groups of three down each side of it. The smaller shrubby plants of allied families were arranged in new beds parallel with them, and these beds were backed by plantations of shrubs and deciduous trees. Avenues, too, were formed among the trees, with the view of giving access to specimens, and having them properly arranged.

The year 1869 saw the opening of the Kew Gardens station of the L.&S.W.R., which necessitated the construction of new entrance gates to the Gardens on the Richmond road, and the erection of a new range of greenhouses devoted to economic plants and orchids. The lake, constructed by Sir W. J. Hooker, was also deepened, and

King William's Temple enclosed within a wire fence. The summer of the year 1870 was marked by a long and continuous drought, which was extremely disastrous to the trees at Kew. Elms, ashes, beeches, and sycamores perished by the hundred. The oldest trees in the grounds were oaks and English elms, the majority of which dated from the reign of George II. The oldest beeches had been planted in the same reign, and having been put in very thickly suffered very keenly from the drought.

Dr. Hooker undertook the formation of a Pinetum on the south side of the lake, no complete public collection of hardy conifers adequately named and properly arranged being in existence in England at that time. Few of the older specimens of pines were used in the laying out of this Pinetum: it consisted in the main of young plants raised from seed in the Kew nursery, supplemented by contributions from the Edinburgh Botanic Gardens. This important collection, perhaps the most extensive in Kew, was completed by the end of the year 1873. It extended along nearly 2000 yards of path and avenue, representing two and a quarter miles of made beds and plantations, except where it was interrupted by old trees. Almost every species capable of being grown in the open air was represented. The plants were arranged as far as possible so that the species of the old world were placed opposite the American species of the same genera, the total number of species in 1872 being about 1200.

In 1872 the *Acacias, Robinias, Gleditschias*, that had been scattered over five acres of ground, were arranged in a broad avenue, leading from the old arch to the Pagoda; the Leguminosæ were classified and replanted in beds parallel to the avenue, the collection of willows and alders was taken to the borders of the lake, and a rose garden was made on the slope of the mound on which stood King William's Temple.

In 1875 it was found necessary to revive the office of Assistant Director, which had been suppressed on the succession of Dr. Hooker to the Directorship ten years earlier. The great increase in the Kew collections, and the expansion of the official correspondence with the Admiralty and the India and Colonial Offices, foreign and colonial governments, travellers and other workers in botanical science made Parliament recognise the necessity for its re-establishment. The new Assistant Director was Mr. (now Sir William) Thiselton-Dyer, formerly Professor in the Agricultural College at Cirencester, the Royal College of Science for Ireland, and the Royal Horticultural Society.

The new appointment was of considerable importance; it set the Director free to undertake almost immediately the journey through a large part of the Western region of North America, to which reference has been made. At the same time the work of development at Kew was able to proceed unchecked. In 1875 a hardy fernery was laid out. The ferns were planted on both sides of a winding path, forty yards long, amongst loose stones which formed a low bank backed by evergreens. The Berberis Dell was constructed in 1876.

During 1877 the collection of economic plants, and the Aroideæ were revised, the fern collection was increased, and the contents of the whole of the beds of hardy shrubs between King William's Temple and the Temperate House were extended and rearranged.

In 1878 the extensive collection of Bromeliaceæ was carefully revised and catalogued by Mr. J. G. Baker, Assistant Keeper of the Herbarium, and an important collection of succulents was exhibited in the south octagon of the Temperate House. In the late summer of the same year a very severe hailstorm did a great deal of damage at Kew, the broken glass amounting to eighteen tons, which necessitated a supplementary vote in the Estimates. The collection of Liliaceæ and Amaryllidaceæ was rearranged, and the tropical Fern House put in order. Two years later the houses were renumbered; they then comprised a tropical house, a house for tropical ferns, another for temperate ferns, a conservatory, a house for succulents, a fern propagating pit, a Cape house, a begonia house, a stove, a Victoria house, two houses for tropical and temperate economics, two others for tropical and temperate orchids, a water-lily house, propagating pits for orchids and for tropical plants, two conservatory reserves, a conservatory forcing house, a succulent reserve house, and a bulb house.

The latter part of the winter of 1880 was extremely severe, and caused a great deal of damage in the Arboretum. Many of the oaks were broken down, several pines were killed, and the hydrangeas, escallonias, and cistuses for the most part perished. Notwithstanding, good progress was made with the classification of the trees, and considerable rearrangements were effected.

Towards the end of 1881 the Rock Garden was formed with the aid of a special grant of £500 from the Treasury. There had been for some time a small collection, dating from 1873, but in this year it was supplemented by the acquirement of Mr. Joad's plants, and a new site was rendered necessary. Such a site was selcted between the wall bounding the herbaceous ground and the new

range of houses. As the surface was quite flat it was necessary to sink a path to get variations of level; one was accordingly made 8 feet wide and 514 feet long, and was so arranged as to give a suggestion of the dry bed of a Pyrenean stream. On either side fragments of rock were piled up as naturally as possible to a height of about 5 feet, care being taken to leave between them deep pockets for the plants, which were filled up with loam mixed with leaf mould. The whole rock garden was thoroughly drained, and 2630 of Mr. Joad's plants were planted out.

A wild garden also was begun during this year, the sloping surface of the hill crowned by the Temple of Eolus being planted with bulbs and spring flowers.

In the Arboretum the collection of yews was lifted and arranged in semicircular beds. The species and varieties of Cedar were collected and arranged in an avenue 165 yards long, leading from the Juniper Avenue to the Heath collection. Many of the rarer ashes were transplanted to make an avenue in that part of the Gardens which lay between the east end of the lake and the garden fence. The collection of Leguminosæ was enlarged; the Terebinthaceæ, Sapindaceæ, and Rhamnaceæ were greatly extended, and the Corylaceæ were arranged in a short avenue leading from that of the beeches to the American Garden. The whole collection of monocotyledonous shrubs was planted in semicircular beds on the east side of the Holly Walk.

While these changes were being effected in the arrangement of the Gardens great additions were made to the Museums.

During the year 1868 some very important contributions were made to them by the Commissioners of the Paris exhibition of 1867, and the large collection of portraits of botanists, botanical paintings and drawings which had belonged to Sir W. J. Hooker was purchased. His Herbarium, which he had lent to Kew, had been also acquired, together with a part of his botanical library and the whole of his botanical correspondence and MSS. The books included "many illustrated works of the greatest rarity and cost, large paper copies, and privately printed books, and a unique collection of botanical pamphlets, extracts, etc. The arranged and bound correspondence comprises about 40,000 letters, dating from 1810, and is of great interest in relation to the history of botany."

In 1869 the Herbarium was enriched by the presentation of two collections of plants, one from the United States the other from Demerara. The incorporation of the great East Indian Herbaria, including those of the East India Company, was completed, the

end of a task that had occupied ten years. In 1871 a very complete and valuable collection of Yarkand plants, the first ever made in that region, was presented by Dr. Henderson; the valuable Indian Herbarium of Dr. Wight, late Superintendent of Cotton Plantations in Madras, which contained more than 4000 species, and the Chilian and Fuegian collections made during the voyage of the "*Nassau*" to the Straits of Magellan also became the property of Kew. In 1872 the Royal Horticultural Society presented to the Museums a fine collection of Mexican pine cones, models of Indian fruits, etc., and Dr. Schweinfurth, the celebrated traveller, gave a very good collection of Central African vegetable products. The Herbarium also received several important novelties, including plants collected by the Rev. C. New on the Alpine zone of Kilimanjaro, then the only visited mountain of Equatorial Africa; also a fine collection of Brazilian plants, and another of Appalachian mosses. Other treasures secured were plants from India and Burmah, with 1850 specimens from Borneo.

During the year 1875 all the products and specimens illustrating the Palmaceæ in Museum No. 2 were entirely rearranged. The separate collection illustrating vegetable teratology and pathology which was commenced in 1874 was considerably augmented and revised. This was the first public collection to illustrate the diseases and the transformations of the organs of plants. Amongst the additions made to the Herbarium in this year was the collection of John Stuart Mill, comprising specimens collected from the Pyrenees to Bithynia.

In 1876 want of room to show properly specimens illustrating the Cryptogams led the Curator to commence a systematic revision of the whole of the collection. The Prince of Wales placed at the disposal of the Kew officials the large collection of fruits, seeds, and woods made during his Indian tour, and the herbarium formed by his botanical collector. During the next year a new building, consisting of a large hall with galleries, was constructed to accommodate the herbarium, and the front of the old building was fitted up for the library. In 1878 the revision of the contents of Museums Nos. 1 and 3 was proceeded with; the herbarium transferred to its new quarters and reinforced by the Indian Herbarium of Mr. Clark, the collection of Dr. Schweinfurth from tropical Africa, and a fine series of North Asian and Japanese plants from the Imperial Garden of St. Petersburg.

In 1879 among other acquisitions of great value was the important Mycological collection of the Rev. M. J. Berkeley, the well-

known writer on vegetable pathology. During this year the museums were greatly enriched; a magnificent collection of timber products presented by the Indian Government in 1878 was safely housed; the India Office transferred to Kew the entire collection representing economic botany, which had formed part of the India Museum at South Kensington, together with some thirty-six tons of wood consisting of specimens that had been lying for years at their stores in Lambeth. The liberality of the India Office went farther than this; it transferred to the Royal Gardens the Indian House belonging to the India Museum, removing and re-erecting it. At the same time it made a munificent contribution of money to the Museums.

In 1880 No. 2 Museum was enlarged, and the Herbarium received the interesting European Herbarium of Mr. Joad, and a very valuable collection of Chinese plants. In 1882 the collection of European and exotic lichens formed by the Rev. W. R. Leighton was acquired by Kew, as well as the very interesting collections of the Rev. R. Baron from Madagascar.

The ornamental side of the garden was also an object of assiduous care. The Director laid out numerous drives, avenues, and paths. A Thorn Avenue was formed in 1868, a Cedar one in 1871, a Holly Walk in 1874, and an avenue of Sweet Chestnuts in 1880.

During the year 1880 the North Gallery was erected and presented to the Nation by Miss North, to contain a large collection of coloured sketches made by her in nearly all the tropical and subtropical regions of the world, with the view of illustrating their characteristic floras.

Under Dr. Hooker's Directorship the supply of plants from Kew to British colonies and dependencies steadily increased. The plants desired by the Colonial Governments were largely economic in their character. In 1869 such plants were sent to Natal, Cape Town, Calcutta, Brisbane, Mauritius, Singapore, Sierra Leone, and Rio de Janeiro, while seeds of the best Manilla and Havana tobacco were sent to all our colonies suited to their cultivation.

In 1870 six more gardeners were sent from Kew to take charge of Indian cotton plantations, making a total of more than thirty Kew employés engaged there in various departments of horticulture and arboriculture. A large number of American seeds, especially of Californian and Rocky Mountain trees, were procured and distributed from the Gardens to the Colonies. The next year a very important step was taken in the sending out of a gardener to re-establish the Botanic Garden in Jamaica. A superintendent

was sent also to the Hong Kong Gardens, and a skilful gardener to Bermuda to form a garden there.

In 1871 a skilful propagator was sent from Kew to superintend the extension of forest plantations in Mauritius, and superintendents were sent to the Agri-horticultural Society's garden at Calcutta, and to the Botanic Garden in Natal.

Papers respecting the disease of the opium poppy were transmitted to Kew from India, to be reported on; as were papers on the ravages of the *Phylloxera*, which was causing so much trouble to the viticulturists of various continental states.

During 1872 large quantities of Liberian and of Cape Coast coffee were sent from the Gardens to the coffee-growing British possessions, and an interesting correspondence was carried on with the Local and Home Governments concerning the diseases from which coffee had for some years been suffering in India, Natal, Ceylon, and other colonies.

During 1876 seeds of several varieties of tobacco were sent to Singapore and to the Bahamas, for cultivation in those colonies. The South American rubber plants, *Hevea* and *Castilloa*, were introduced into India. Other industries which were similarly fostered were the cinchona industry in Jamaica, and silk culture in the Australian colonies. In aid of the latter Kew distributed to them the most valuable kinds of mulberries used in Kashmir and North-west India.

The results of investigations into the origin and nature of the sugar-cane disease were communicated to the government of Queensland, where it had done much damage. In 1878 a beetle, *Sidendactylus*, very destructive to grape-vines, which had been imported into the island of Ascension from South Africa, was reported on at Kew; as was also another insect, *Oryctes monoceros*, very destructive to the coco-nut in Zanzibar. Other inquiries into parasitic diseases, both animal and vegetable, were made the object of investigation. In 1879 Marshall Ward, many years later Professor of Botany at Cambridge, commenced his career by going out to investigate the coffee-leaf disease in Ceylon at the instigation of the Colonial Office on the recommendation of the Director.

But the enterprise of Kew in the direction of research did not end here, for a new departure that had far-reaching results was made in 1874. The Commission on Scientific Instruction and the Advancement of Science had recommended in its fourth report that opportunities for the pursuit of investigations in Physiological Botany should be afforded in the Royal Gardens. Though this

suggestion met with little sympathy in Government circles it was quite otherwise with the Kew authorities. The Director and Mr. Thiselton-Dyer especially had marked with great interest and appreciation the new departure which was being taken in Germany under the influence of Sachs, and both ardently desired to see the introduction of similar work into England. The old eminence of this country in the days of Grew, Hales, and Knight had apparently vanished, and was in danger of being actually forgotten. Thiselton-Dyer had laboured earnestly, and was still labouring, both by influence and example, to bring about a change, organising lectures and promoting laboratory work, and gathering round him an ardent band of the younger men. Marshall Ward, Vines, Bower and many others in this way entered on the scene of what was to prove later on an eminently successful career. The Kew influence was thus all on the side of the Commission, and soon after the report appeared a personal friend of Sir Joseph Hooker, Mr. T. J. Philips Jodrell, built and equipped at the Royal Gardens the modest laboratory which still bears his name, and which has been the scene of much activity carried on by many botanists, the fruit of whose labours has appeared in most of the prominent scientific journals.

The Laboratory, which was originally intended to be associated with the Herbarium, was actually located in close proximity to the herbaceous ground; it was equipped and opened in 1876. It is noteworthy that the first to use it for research was the eminent physicist, Professor Tyndall.

The history of the Jodrell Laboratory and of the work done in it falls largely into a subsequent section. But its foundation was one of the most notable events in the history of Kew during this period.

Activity in all departments thus marked the administration of Kew during the years which we are now discussing. Sir Joseph retired from Directorship in 1885, being succeeded by the Assistant-Director, his son-in-law, Professor (now Sir William) Thiselton-Dyer.

Sir Joseph D. Hooker was exceptionally fortunate in the other colleagues who were associated with him at Kew. Prominent among them stood Daniel Oliver, for many years Keeper of the Herbarium. He succeeded Lindley as Professor of Botany in the University of London in 1861, and held the Chair till 1888. He was the recipient of a Royal Medal at the hands of the Royal Society in 1884, and was awarded the Linnean Medal in 1893. Another helper, Charles Baron Clarke, though not officially attached to

Kew, was occupied there for many years, working with Hooker at the *Indian Flora*. He was born in 1832, and educated at Trinity College, Cambridge, afterwards becoming Fellow of Queens' College. His career was mainly an Indian one, for he became attached to the Bengal Education Department in 1866. Being a botanist then of considerable attainment he took temporary charge of the Royal Botanic Gardens at Calcutta, and of the Cinchona cultivation in Bengal. He returned to England in 1877, and after a furlough of two years he was associated with Hooker in the preparation of the *Flora of British India*. He spent a further term of four years in India, 1883 to 1887, before he retired from the service and went to reside at Kew.

During his Indian life he was an ardent explorer of the botany of the country as far as his official duties permitted. He visited a very large number of its provinces: Bengal, Assam, the Khasia Hills, Tipperah and Chittagong, Sikkim and the Himalayas, Madras and the Nilgiris, the Delta of the Ganges, Kashmir and the Karakoram range—so widely, indeed, did he extend his researches that his knowledge of the *Indian Flora* was comparable with that of Hooker. In 1877, when he returned to England for the first time, he brought with him a collection of 25,000 specimens, representing 5000 species, which he presented to Kew. His writings were numerous, and included Monographs of several Natural Orders. After 1876 he specialised on the Cyperaceæ, on which he became the recognised authority; indeed the articles on the group in the *Flora of British India*, the " Flora Capensis " of 1901 and the " Flora of Tropical Africa " of 1903, are by his pen.

There was also John Gilbert Baker, for more than thirty years a notable figure in the Herbarium, of which he became Keeper on the resignation of Professor Oliver in 1890. Like his predecessor he was awarded the Linnean Medal, receiving it in 1899. Two years earlier he had been presented with the Victorian Medal of the Royal Horticultural Society. Both Oliver and Baker contributed many writings to the literature of the time, dealing with both English and African Floras.

CHAPTER XLVIII

GEORGE BENTHAM

THE second of the great taxonomists who made such a mark on the age was George Bentham, born in 1800, a nephew of the celebrated Jeremy Bentham. During his early life his parents were for the most part resident abroad, and his education was mainly conducted in different continental towns. His first botanical studies dated back to 1817, when he made acquaintance with De Candolle's *Flore Française*. His tastes in this direction were fostered by his mother, who had long been acquainted with Aiton and Forsyth, whose work has already been discussed in these pages. The methodical arrangement of De Candolle's book appealed strongly to the lad, and his work with it had a great influence on the ultimate course into which his life was directed.

For several years afterwards his family was resident in the South of France, with whose Flora Bentham made himself familiar, working at it with much enthusiasm, and becoming acquainted with the leading botanists of Montpelier and the district.

The year 1823 saw a considerable development of his experience, for it brought him back to England, and led to his forming friendships with many of the botanists with whom in after life he was closely associated. Regarding himself still as an amateur, and having at that time no definite intention of devoting his life to botany, he yet seized every opportunity of becoming known to the great leaders of the time. He obtained introductions to them whenever possible, and cultivated their acquaintance by attending such scientific meetings as came within his opportunities. In this way he became known to Sir J. E. Smith, the President of the Linnean Society, who gave him a very cordial reception. In England he formed the acquaintance of T. Andrew Knight of the Horticultural Society, of Robert Brown, Joseph Sabine, and Lindley. Going on to Scotland he very quickly made a friend of Sir W. J. Hooker at Glasgow, a visit to whom was largely instrumental in determining his career. While there he met Arnott, afterwards one of Hooker's successors in the Glasgow Chair, and this meeting paved the way for their association two years later in a memorable journey to the Pyrenees.

In company with Arnott Bentham did a good deal of botanising in Scotland and the Lake District. In this way he spent a very memorable year, for he developed a definite fixity of purpose. He made many influential friends, and through them he came into touch with the Royal Horticultural Society, which he served subsequently as Secretary for many years.

His botanical explorations in France and in Great Britain had developed in him a great liking for such work, and he shortly afterwards projected an extended tour in the Pyrenees, in which he persuaded Arnott to take part. After a preliminary trip to several parts of Spain, they started in the middle of June 1825, returning in August, and bringing with them more than 32,000 specimens of 1200 species, many of them great rarities. An account of this trip, entitled *Catalogue des Plantes des Pyrenées et du bas Languedoc*, was published in 1826, and was the first important contribution to literature which came from Bentham's pen. Written while he was little more than a student, it afforded evidence of a deep sense of the importance of accuracy of identification, while it gave proof that its author possessed a highly developed critical faculty.

Up to the time of undertaking this journey Bentham had entertained serious ideas of devoting himself to the legal profession, to which indeed he had given much time and study. The exploration and its results, however, so strengthened his leanings towards taxonomy that he weakened in his attachment to law and ultimately abandoned it, and gave thenceforward all his energies to botanical work. The definite change of purpose was coincident with his marriage in 1833.

Bentham's botanical life in England began by an association with Wallich, the great Indian collector, in the distribution of his enormous accumulation of plants. Up to his marriage he was occupied chiefly with arranging the Labiatæ of this collection. He found the Order in such confusion that he set himself to make a complete revision of the genera, a task which he accomplished with much skill in 1832. Two years before, at the instance of Joseph Sabine and Lindley, he accepted the honorary secretaryship of the Horticultural Society. This brought him into close relationship with Knight, whose friendship he enjoyed till his death in 1838, and whose literary executor he became.

The year 1830 was memorable in his life for the commencement of a close intimacy with the illustrious Alphonse de Candolle, to whose great *Prodromus* he subsequently made substantial

contributions. His chief botanical work was his collaboration with Graham in the examination of the Leguminosæ of Wallich's collection.

In 1831 he was occupied with Cumming's Chile and Peru plants, and he prepared for the Press the first part of the *Labiatarum Genera et Species*, completing it during the next year.

It is of some interest to note that at the meeting of the British Association in 1833, the year of his marriage, Bentham was requested to prepare a report on systematic botany, as the incident bears an eloquent testimony to his reputation. He accepted the task, but for various reasons the report was not presented till forty years later. It was a wonderful piece of lucid writing, extremely comprehensive, and of great value as presenting the history of the development of taxonomy from the time of Linnæus.

It was in 1839 that Bentham first made the acquaintance of Dr. Joseph Hooker, his collaborator in later years, and thenceforth his life-long friend. He also met for the first time Asa Gray, who was then visiting England.

During the years succeeding his marriage his old friendship with De Candolle bore fruit. The celebrated *Prodromus* of the De Candolles, father and son, was in course of publication. They enlisted the assistance of other botanists, entrusting to them the preparation of monographs of separate groups. Among these helpers Bentham was not the least conspicuous, his work being extremely accurate, lucid, and precise. In 1839 he finished his first contribution—a monograph of the Ericaceæ, which was the forerunner of several others.

About this time he was at work upon the plants collected in Mexico by Hartweg, who had undertaken a tour of exploration there at the instance of the Horticultural Society, and who had sent home a large number of specimens. His official position with the Society led to their being placed in Bentham's hands, and he described and catalogued them, publishing his results in 1839 as *Plantæ Hartwegianæ.*

It was in 1840 that the Government made proposals to break up the Kew collections and distribute them to the Horticultural and Botanical Societies, as we have already seen. This proposal would have been practically a death-blow to Kew had it been carried out; it was strenuously resisted, and its defeat was largely due to the activity of Bentham.

In 1852 Bentham was instrumental in procuring for Cambridge a very important contribution to the herbarium there. His

friend, Dr. Lemann, had accumulated a very large collection of plants, and on his death in this year he left it in Bentham's charge. The plants occupied no less than thirty-two large cases, and needed much labour to make them suitable for University use. With the aid of an assistant from Kew and other helpers Bentham undertook the task and dispatched in May 1853 a first instalment, consisting of eight cases of plants, " selected, determined, laid down and labelled." At intervals afterwards he was engaged with them, and it was not till 1860 that the gift was complete. In the final stages Bentham had the help of Daniel Oliver, later Keeper of the Kew Herbarium. The whole occupied much of his time during seven years.

With all this busy activity it may be noted that the period of his life 1842-54 was primarily occupied with his contributions to the *Prodromus* to which we have alluded.

With the year 1854 came a change in his life which had most momentous results for botany. He had practically finished what he had proposed to do for De Candolle, and for a while was inclined to look upon his botanical work as ended. His great modesty had always led him to look upon himself as a mere amateur in that field, and to depreciate what he had achieved. Possibly some morbid feelings at the time came up in his mind; the labour and expense of keeping together his splendid herbarium and library tended to depress him, and he seemed suddenly to take a very pessimistic outlook on the future of his scientific career. He proposed, therefore, to hand over his collections to Kew, and to retire from active botanical work.

Difficulties, however, arose about the acceptance of his generous gift. Meantime his ideas of abandoning botany were energetically combated by Sir W. J. Hooker, who was successful in offering him some definite programme of work and such facilities at Kew as led him to reconsider the position. Sir W. J. Hooker set apart for him a private library for his own work, and arranged with him to incorporate his botanical treasures with those of his own herbarium now housed at Kew, though not the property of the Department. He also enlisted his help in a scheme which had been for some time contemplated at Kew, the preparation of a series of Colonial floras, based upon the accumulations in the herbarium. Bentham lent a willing ear to the suggestion, and took the work eagerly in hand, spending most days from ten to four at Kew. He began at once with the *Flora of Hong Kong*, which was soon a model for the rest. This work, which was

published in 1861, was the first outcome of what proved to be the final period of Bentham's activity, for he remained thus informally associated with Kew till his death.

The service which Sir W. J. Hooker rendered to botanical science in thus securing Bentham's co-operation at Kew, will be seen when it is remembered that the years he spent there saw the appearance of the *Flora Australiensis* and the *Genera Plantarum*, besides a number of works of minor importance.

The second of the Colonial floras which Bentham wrote was the great *Flora Australiensis*, which appeared in seven volumes between the years 1863 and 1878. In its execution he had some collaboration from Ferdinand Müller, the great Victorian systematist, but it represented for himself the record of some sixteen years' continuous toil.

It was while these labours were proceeding that the inception of the *Genera Plantarum* was undertaken. In collating and describing the mass of material which was under his control at Kew he was embarrassed a good deal by the inadequate delimitation of genera. It was in consequence of this that he projected the task of writing a new work, which he ultimately carried out in conjunction with Sir J. D. Hooker.

The *Genera Plantarum* was the last task of his life. No sooner was it finished than old age seemed to settle down upon him; he could not take up anything again with the old enthusiasm, and he gradually sank till his death in somewhat less than a year.

During this later and final period of his life much happened outside the sphere of his actual work, in which he played no unimportant part. He was elected President of the Linnean Society in 1861, having been a member since 1828. There is little doubt that he would have held the chair till his death had not an unfortunate difference of opinion between himself and some of his colleagues led him to resign it in 1874. During his Presidency the Society's library, collections, and portraits were removed to the new rooms at Burlington House, the arrangements being carried out under his personal supervision, and much of the work done by his own hands. In 1862 he was elected to the Fellowship of the Royal Society; in 1874 Cambridge gave him the honorary degree of LL.D.

Bentham's life after his marriage shows one long record of continuous toil, during which he handled collections of plants from almost every quarter of the globe, describing and arranging them with infinite patience and unequalled skill. In this work

he brought to bear, in the words of one of the most eminent of his colleagues, " an insight of so special a character as to be genius into the relative value of characters for practical systematic work—a sure grading of essentials and non-essentials."

His writings were voluminous, some of them monumental. It would be impossible here to narrate even the titles of them all, though a passing allusion has been made to the most important. One other calls for notice, not so much for its magnitude as for the great usefulness it has been found to possess for students of the plants of their own country. This was the *Handbook of the British Flora*, begun in 1853 and published in 1858. It seemed as if he undertook it in the first instance as a species of relaxation, for in the earlier years at least of its compilation Bentham rather amused himself with it before breakfast. It was a wonderful book for students, clear, precise, and easy to use. His remarkable power of systematising large masses of detail was very apparent in it, things being so put as to enable a new specimen to be identified with economy of time. It naturally passed through several editions, ultimately coming under the care of Sir Joseph Hooker after Bentham's death. Professor Oliver said of it that it was " remarkable for terseness and precision, and for the judicious selection of diagnostic marks, and the instinctive estimate of probable range in variation."

As we shall see in a subsequent section Bentham was not silent on the principles of classification, several modifications of certain of the larger groups finding their way into the *Genera Plantarum*. In 1877 he proposed a scheme for the subdivision of the Monocotyledons in connection with his work on the *Australian Flora*. He formed four main groups between which he distributed the Natural Orders. These were the following:—

ALLIANCE 1. *Epigynæ*.—Ovary inferior: Perianth usually biseriate.

,, 2. *Coronariæ*.—Ovary superior: usually syncarpous. Perianth usually biseriate. Seeds albuminous.

,, 3. *Nudifloræ*.—Ovary free: monocarpous, apocarpous or rarely syncarpous. Perianth O or reduced to a small scale under each anther. Seeds with or without albumen.

,, 4. *Glumales*.—Ovary free: monovulate or with monovulate cells. Flowers usually in heads or spikelets within glumes. Perianth either O, or scarious or glumelike and usually concealed within the bracts. Seeds albuminous.

We have already spoken of the attitude Bentham took in the controversy that followed Darwin's first promulgation of what ultimately became the *Origin of Species*. In looking at the

position he took up we must remember how he had been all his previous life an unquestioning adherent of the dogma of the constancy of species. He wrote himself in 1863: "I can scarcely think that due allowance is made for those who like myself through a long course of study of the phenomena of organic life had been led more and more to believe in the immutability of species within certain limits, and have now felt their theories rudely shaken by the new light opened on the field by Mr. Darwin, but who cannot surrender at discretion so long as many important outworks remain contestable." Later on, however, he gave in his adhesion to the theory, though the necessity of abandoning long-cherished convictions brought him "severe pain and disappointment." In 1874 we find him writing: "Fifteen years have sufficed to establish a theory, of which the principal points, in so far as they affect systematic botany, may be shortly stated as follows:—

"That although the whole of the numerous offspring of an individual plant resemble their parent in all main points, there are slight individual differences between them.

"That among the few who survive for further propagation, the great majority under ordinary circumstances are those which most resemble their parent, and thus the species is continued without material variation.

"That there are, however, occasions when certain individuals with slightly diverging characters may survive, and reproduce races in which these divergences are continued, even with increased intensity, thus producing *varieties*.

"That in the course of an indefinite number of generations, circumstances may induce such an increase in this divergency, that some of these new races will no longer readily propagate with each other and the varieties become *new species*, more and more marked as the unaltered or less altered races, descendants of the common parent, have become extinct."

Bentham died in 1884, to the great loss of botanical science. He had done a prodigious amount of work in systematic botany, employing to the utmost his wonderful endowment of accuracy, discrimination, and precision, and exercising in all his writings a judgment and a lucidity which renders his reputation comparable with those of Linnæus and Robert Brown. In his work on taxonomy it has been well said by Hooker that there was scarcely an Order which he did not more or less remodel. He had a wonderful power of grasping those details of structure which are important for classificatory purposes, and possessed with this

a perfect genius for criticism of all such matters. With all his wealth of knowledge and his critical acumen he was essentially modest in his appreciation of his own powers, and never shrank from seeking the opinions of other workers on all points with which he distrusted his familiarity. Moreover, he laid down for himself limitations beyond which he would not go, particularly in the direction of the new morphology, with which, however, he was fully sympathetic. His own gifts lay in the direction of systematic work, and here he was almost unrivalled. Exactitude of detail was with him a principal object, and a discriminating and judicial spirit he always brought to bear upon what he was engaged in. His patience and assiduity in labour were phenomenal.

His attitude to the new biological movement was sympathetic, but his adhesion was given only after mature consideration and logical conviction. He had no tolerance of mere speculation, but was ready to give a hearing and bring a reasoned judgment to bear upon hypotheses based upon experimental evidence, and was willing to submit taxonomic generalisations to the same standard.

It is remarkable with what completeness he adapted his old views to the new line of thought. With the total change that the disappearance of the idea of fixity of species brought into taxonomy Bentham reconsidered his position, and gradually reconstructed the basis on which he rested it. He put forward the new ground in the following terms:—"The races whose relations to one another we study can only be present to our minds in an abstract form. In treating of a genus, a species, or a variety, it is not enough to have one individual before our eyes; we must combine the properties belonging to the whole race we are considering, abstracted from those peculiar to subordinate races or individuals. We cannot form an idea of a species from a single individual, nor of a genus from a single one of its species. We can no more set up a typical species than a typical individual."

CHAPTER XLIX

THE "GENERA PLANTARUM" OF BENTHAM AND HOOKER

Both Bentham and Hooker were engaged during many years in dealing with the description of enormous numbers of plants which had poured into Kew from widely separated regions of the world, with the recognition of species, their aggregation into genera, and the precise delimitation of these larger groups. In the absence of such classification the material was of little value for research. The difficulty they encountered at the outset of recognising the delimitations of genera was extremely great. There was but little that was authoritative about such groupings as they found. Genera plantarum had been drawn up by Linnæus and by De Jussieu in the eighteenth century, and by Endlicher in 1836-40, but the delimitations were based upon a relatively small number of plants, and were of little use in dealing with these large exotic collections. Feeling the need of a new authority, both botanists for a long time contemplated engaging in the task of its production, but the colossal labour involved deterred them. In 1857 they somehow became aware of each other's separate purpose, and at Hooker's suggestion at once agreed to collaborate in producing it.

From the outset their plan was not, like that of De Candolle and the other systematists, to formulate a complete scheme. The authoritative delimitation of genera came first—they would do indeed for genera what Linnæus in his day had done for species. Bentham recognised that a satisfactory scheme of classification must begin by the accurate definition of the smaller groups, which could then later be aggregated together on the lines of general correspondence and relationship. The failure of Lindley's schemes had arisen partly from the non-recognition of this principle and by his efforts to work in the opposite direction.

The arrangement from the outset was accordingly based upon the lines of the De Candollean scheme, and its object seemed to be to extend and complete the latter rather than to supersede it. There were many reasons that could be advanced for this method of procedure. Lindley's proposals, even the last edition of the *Vegetable Kingdom*, which had been revised by Bentham, and issued only four years before, were already out of date, and his views of

the affinities of many of his Natural Orders had come to require reconsideration, while the principles on which he had based his divisions were proving insufficient for the uses to which he put them; nor had any better scheme come into general acceptance. After a careful scrutiny of Lindley's schemes in the light of subsequent discoveries Bentham pronounced for the De Candollean proposals on the grounds of their practical convenience and their general adoption in the floras of the time. Not that he thought lightly of Lindley's work, for he spoke of his writings as having more than any others tended to the final acceptance of the Natural method in England.

Possibly Bentham's close association with the De Candolles, both father and son, may have led him on other grounds to prefer their scheme. It will be remembered that he had contributed several monographs to the great *Prodromus*. Moreover, his own early training was altogether De Candollean. "My apprenticeship to the science from 1817 to my first botanical publication in 1826 was entirely under the guidance of De Candolle's Flora and 'Theorie.'" Failing Lindley again, there seemed nothing else, unless the collaborators were prepared to put forward a new system of their own.

So the De Candollean system was taken as the basis, but it was not slavishly adhered to. The main divisions of the Dicotyledons were retained, but Bentham and Hooker introduced a fifth subclass, the Disciforæ, based on the existence of a disc, raising this feature to a high order as a diagnostic character. The Monochlamydeæ and the Monocotyledons were more thoroughly revised, and a new series of Natural Orders formulated in them.

Bentham himself has left on record the plan on which the whole work was constructed.[1] He says it "has been to prefix to each volume a methodical diagnosis or short conspectus of the most striking characters of the several orders contained in the volume and under each order to give the following particulars:—

"(1) The general characters of the Order.
"(2) A short sketch of its geographical distribution.
"(3) An equally abridged sketch of its affinities.
"(4) An enumeration of the aberrant forms observed in individual genera, an addition which is, I believe, here introduced for the first time, we having both of us long felt the want of it in general works.

[1] *Brit. Ass. Rep.*, 1874, p. 42

"(5) A conspectus of the genera—that is, a short and as much as possible contracted exposition of the most salient characters of each genus, as a guide to the determination of plants. Where the order is large enough, or heteromorphous enough, to be subdivided into distinct suborders or tribes, the tribal characters are given in this conspectus; and where the tribes are numerous, as in Leguminosæ, Umbelliferæ, Rubiaceæ, and Compositæ, a short conspectus of them precedes that of the genera. This arrangement into tribes has been everywhere thoroughly investigated, and in the case of most of the large orders entirely recast.

"(6) An enumeration of genera which are either so nearly allied that they might be supposed to belong to the Order, or which have been erroneously included in it, or have been so imperfectly described as to be wholly doubtful.

"(7) Then follow the detailed characters of each genus, with an evaluation of its extent, its geographical distribution, a full synonymy, references to plates illustrating it, and such occasional notes as appeared necessary on affinities, on genera confounded with it, or in our opinion unadvisably separated from it. Where the genera are sufficiently large or varied, the characters of their primary sections are entered into."

In their collaboration the authors decided every important question after joint consideration and discussion; the limits of the characters of the larger groups, the descriptions of the Natural Orders, their subdivision and the arrangement of genera were settled by mutual interchange of views. Each read and criticised the work of the other before it went to press. The Latin text was revised for press by M. J. Berkeley.

Bentham's description of the plan correctly represents the finished work. The diagnostic characters of the Natural Orders are drawn up with the same care as those of the genera. All are clear, and exactly comparable; affinities, exceptional forms, abnormalities—all are carefully noted. The approximate number of known species belonging to each genus is given, and much care has been taken to set out the details of geographical distribution and synonymy as fully as possible.

All important characters were revised and verified before being

attributed to a genus; the descriptions were written with special reference to the specimens preserved in the herbarium at Kew. If in any case a particular genus was not well established or was based on insufficient characters it was reduced to a sub-genus or its name perhaps found to be a synonym.

But to convey the idea that the great work is but an authoritative description of Natural Orders and genera would be to give a very inadequate impression of its value. It shows an enormous amount of care and critical knowledge in its treatment of the internal classification of the larger orders. Over and over again we come to instances in which the whole treatment of the genera is entirely novel. The large numbers of species are as carefully grouped and arranged within the genera as are the genera in the Natural Orders. Here we have work which was entirely new, which demanded an almost infinite patience, combined with a critical acumen rarely met with in the history of the science. Still so unobtrusive was the work that it very largely escaped recognition, and was certainly never appraised at its true value. It is one of the features which have made the *Genera Plantarum* so valuable.

Moreover, though the authors did not put forward even the outlines of a new system their work shows that they had not closed their eyes to its importance. Though they worked on the lines of De Candolle, and in the main followed his sequence in the arrangements of the Natural Orders they discussed more fully their true affinities. Under each order its natural relationships are so clearly set forth that we have in their work the material from which a new classification could be set out without much difficulty. It was perhaps unfortunate that the time of the construction of the work came when it did; the framework of the scheme had been drawn up before Darwin's hypothesis took shape. When the question arose of adhering to the original plan or substituting a new one on Darwinian lines it found the collaborators not in perfect agreement upon the new views; it found those views in need of careful scrutiny and considerable enlargement before a comprehensive scheme could be thought out. It was perhaps inevitable that so large a measure should be deferred awhile till the new views should have assumed a clearer definition and limitation. Under the circumstances Bentham and Hooker went as far as was at the time practicable in that direction. That they were successful has been shown by the use, not always authorised, that has been made of the *Genera Plantarum* by continental writers.

The outlines of the scheme of the work were the following:—

PHANEROGAMIA
- ANGIOSPERMIA
  - *Dicotyledones*
    - Polypetalæ—
      - Thalamifloræ
      - Discifloræ
      - Calycifloræ
    - Gamopetalæ
      - Inferæ or Epigynæ
      - Superæ
      - Dicarpeæ
    - Monochlamydeæ or Incompletæ
      - Curvembryæ
      - Multiovulatæ aquaticæ
      - Multiovulatæ terrestres
      - Micrembryæ
      - Daphnales
      - Achlamydosporeæ
      - Unisexuales
      - Ordines anomali
  - *Monocotyledones*—
    - Microspermæ
    - Epigynæ
    - Coronarieæ
    - Calycineæ
    - Nudifloræ
    - Apocarpæ
    - Glumaceæ
- GYMNOSPERMIA

The series of the Polypetalæ and Gamopetalæ were divided into cohorts—those of the Monochlamydeæ and of the Monocotyledons were not. Indeed the series of the latter are more on the level of the cohorts of the former. All are divided into Natural Orders. The Gymnospermia are divided into three so-called Natural Orders, whose importance, however, is considerably greater than that of the similarly named groups of the Angiospermia, indeed they are more nearly comparable to the sub-classes.

When we compare these proposals with those of De Candolle we see certain if not conspicuous advances upon the latter. The groups are more evenly balanced; a third sub-class has been introduced between Thalamifloræ and Calycifloræ, and a totally new classification has been adopted for the Monochlamydeæ and the Monocotyledons based upon differences of internal structure as well as upon the more conspicuous morphology.

With all this, however, the chief merits of Bentham and Hooker's great work lie below the surface. It is not until we study the arrangements in the orders and the illuminating treatment of the genera and species that we realise how great it is, and what light

it has thrown upon Natural Affinities. One can nevertheless regret that the great idea of Phylogeny as the true clue to classification had not dawned upon the world a generation sooner so that the guidance it gave might have been more fully manifested in this masterpiece.

The work appeared in three large volumes: the first, in two parts, was published in 1862 and 1865, the second in 1873, the last in 1880.

Bentham has told us with some completeness the story of the collaboration[1] and the share that each of the colleagues took in the work. The orders of the Polypetalæ were pretty equally divided between them. Bentham took the bulk of the Thalamifloræ, Hooker being responsible for the Cruciferæ, Capparideæ, and Resedaceæ; Hooker did all the Disciforæ except Lineæ, Humiriaceæ, Geraniaceæ, and Olacineæ, which fell to his colleague. Bentham took the Leguminosæ, the Myrtaceæ, the Umbelliferæ, and the Araliaceæ, while Hooker did the rest of the Calycifloræ. The first part of the second volume was chiefly devoted to the Rubiaceæ and Compositæ. Hooker gave a great deal of time to the former, together with their allies the Caprifoliaceæ; Bentham worked meanwhile at the Compositæ. The great mass of the Gamopetalæ occupied the second part of this volume; Bentham took the Campanulaceæ and their allies, Hooker the Vacciniaceæ, Ericaceæ, Epacrideæ and their allies, the Myrsineæ, Primulaceæ, and part of the Sapotaceæ.

In the third volume, which dealt with the old group of the Monochlamydeæ, Hooker worked up the Curvembryous Orders from Nyctagineæ to Batideæ, and the Nepenthaceæ and Cytinaceæ, and Balanophoreæ, while Bentham did the rest. Of the Monocotyledons Hooker did the Palms, while Bentham did the Orchideæ and the Gramineæ; they divided the rest of this large group between them, Hooker taking the Nudiflorous Orders, and Bentham the Apocarpæ.

While recording the account Bentham gave of the division of the authorship, some remarks of Sir Joseph Hooker's in the sketch of his colleague given in the *Annals of Botany* for 1898 may well bear quotation: "Bentham's *magnum opus* is unquestionably the 'Genera Plantarum,' issued under the joint authorship of himself and the contributor of this memoir to the Annals; but which, whether for the overwhelming share of the work which Bentham undertook, or for the aid he gave his partner in certain Orders elaborated by the latter, may justly be regarded as on the whole the product of one botanist."

[1] *Journal of the Linnean Society*, 20, 304.

CHAPTER L

BOTANY AT THE UNIVERSITIES AND OTHER PUBLIC INSTITUTIONS

Lawson

THE movement of which Daubeny was at the head at Oxford, the development of scientific agriculture, passed out of the purview of the University at his death in 1867. His successor was a man of a different type, and though in many ways in favour of an active policy in the development of botanical teaching his ways were not Daubeny's, nor did he care very greatly for experimental work upon his predecessor's lines, so that the departure the latter had inaugurated languished to practical extinction. Marmaduke Alexander Lawson was educated at Trinity College, Cambridge, and was elected to the Sherardian Chair in 1868, at the age of twenty-eight. His policy at Oxford was a new one; he was deeply stirred by the extension of botanical teaching on the lines of the great modern revival under the influence of Huxley and Dyer, which we shall consider in more detail in a subsequent chapter, and throughout his tenure of the Professorship he made it his chief aim to secure its adoption at Oxford. Animated by this desire, and working for its realisation, it is not surprising that work on the old lines was soon suspended. Lawson did little after he had settled down at the University before the new movement began in London in 1872, and he threw himself into it soon after.

Apart from this introduction of laboratory methods into Oxford his Professorship was marked by several incidents of note. In the early seventies a plan was put forward to transfer the Botanic Garden from its position near the Cherwell to a new site in the Parks, five acres of ground there being marked off for it. It was understood that Sir W. J. Hooker was in favour of the scheme, which had also been approved of by Daubeny before his death. It was very strongly opposed, however, by many of the leading men in Oxford, and met with very little support from Dr. Joseph D. Hooker, then Director of Kew Gardens. Fortunately, as most people think to-day, the proposal was defeated, and Lord Danby's garden was permitted to remain the centre of botanical study at the University.

A further incident of some importance followed. In 1876 the University and Magdalen College reviewed the terms of the lease, and a new instrument was drawn up between them, in virtue of which the rent was fixed at £30 per annum for sixty years. To secure this the University agreed to spend a sum of nearly £6000 on buildings, and gave the College a veto on any removal of trees, and on the erection of all buildings, whether temporary or permanent, which they might consider unsightly or prejudicial to their property. It was further stipulated that if the land should cease to be used as the principal Botanic Garden of the University the College should have power to determine the lease. This precaution seems to have had a very decided reference to the dispute about the Parks site which had been healed only a few years before.

It may be mentioned in view of the amicable relations existing between the College and the University that a year or two after the end of the century the College on its own initiative reduced the rent of the garden under the lease to ten shillings per annum.

It will have been noticed that under Sibthorp's will the new professorship which he founded was to be tenable with the Sherardian Chair. This arrangement continued until the time of Lawson, who was the last professor to hold both. In 1877 a University Commission sat at Oxford, and by one of its statutes the two Chairs were separated. Under a further scheme drawn up in 1883, and passed by the Chancery Division of the High Court of Justice, the election to the Sibthorpian Professorship was placed under a new board of electors, and new regulations were formed for the tenure of the post. The election was to be for three years, at the end of which the Professor might be appointed for a further similar term, but no one was to hold the Chair for a longer period than six years. Under these new statutes, when Lawson resigned two separate botanical professors were elected.

Professor Lawson was a man of comparatively little enterprise in the case of the Garden, and few improvements were effected under his superintendence. Under the provisions of the new lease the University spent £2200 upon the wall and the Lecture Room, and built a Class Room and small Laboratory adjoining, removing some dilapidated greenhouses to make room for them. Lawson made a great effort to secure the erection of some new Glass Houses, but the scheme was not carried out till nearly twenty years later.

In 1883 Lawson resigned his Chair to become Director of the

Government Cinchona Plantations, Park and Gardens, Nilgiris. Two years later a botanical department for the Presidency of Madras was created, and he was made its head as Government Botanist and Director of the Cinchona plantations. He was stationed at Ootacamund, India, where he died in 1896.

Lawson was keenly sympathetic with the study of vegetable histology, which was making its way into favour in England during his career at Oxford. He took, indeed, quite an active part in its introduction, and did all in his power to establish it in Oxford, arranging systematic work both theoretical and practical. A fuller discussion of his activity may be postponed till later.

Babington

It cannot be said that during these years much enthusiasm was manifested at Cambridge. Henslow, who had been practically non-resident for many years, died in 1861, and was succeeded as we have seen by Professor Babington, then one of the most indefatigable of British botanists. But the new occupant of the Chair was by no means in his first youth, and he did not continue to display as much energy as had characterised him in his earlier days.

The subject on which he had been for so long engaged again claimed his attention, and he resumed those researches on the Rubi which had already contributed so greatly to his reputation. But he preferred the study and the herbarium to the lecturer's platform, standing out thus in marked contrast to his predecessor. Unfortunately, but little actual result attended his researches during the early years of his Professorship. He had already issued his principal books, as we have seen, and the new *Flora of Cambridgeshire* was meeting with general acceptance. Except scattered memoirs nothing more came from his pen till 1869, when what many consider his *magnum opus* appeared. Always a keen and talented specialist on the particular group which was its subject, the new work, the *British Rubi*, was to have been the enlargement and completion of his synopsis of the same group written in 1846. Illustrations on a large scale were to have appeared as a separate volume of plates executed by J. W. Salter. Unhappily the death of the artist prevented the completion of this plan, to the lasting disappointment of the author, who was never able to discover another collaborator competent to replace him. This sadly hampered Babington, and prevented him from carrying out

what he hoped to make the completion of his design. Still, the value of the book to the systematist can hardly be over-estimated. It contained a wealth of description of forty-three species and twenty varieties that had never been equalled; all the minute details of habit, clothing, leaf form, and margination were given, together with an invaluable commentary on each specimen. Beside the description and the comments upon it the author traced out its geographical distribution through the British Isles as far as was then known.

The treatment of this difficult group brought out a feature of Babington's work which was almost equally prominent in his *Manual*. He was painfully anxious for accuracy in minute details, a feature which renders his diagnoses so generally valuable. Perhaps he carried this anxiety too far, for it led him to a caution in making pronouncements which led his students in some cases to be somewhat impatient with him, thinking him scarcely so well-informed as they had expected to find him on some points of identification of specimens they submitted to him.

After the publication of the *Rubi* Babington withdrew more and more from active life, and so far as teaching went his Chair became practically a sinecure. The development of botanical study on the lines of Sachs, as we shall see, began at about this time, and was accompanied by a falling off in the older teaching. As a consequence he ceased to lecture in the year 1884, and thenceforward was seen less and less frequently as time went on. He made no attempt to come into line with the modern work, with which, indeed, he had little sympathy.

Babington's books were arranged in the main on the system of De Candolle, but he made no particular effort to modify the latter in the light of recent discoveries or speculations. Nevertheless, in the successive editions of his *Manual* he harmonised English work with that of the Continent, helping thus to do away with the isolation of English science which had resulted from the political complications of the time. He seemed, however, to take little interest in the larger matters of classification, and to confine himself to rigid delimitation of genera and species. He held the Cambridge Chair till his death in 1895, but he was no longer a prominent figure in the botanical world after about 1884. At his death he left his Library and his Herbarium, containing 50,000 sheets, to the University. He was a prolific writer on systematic botany, having published 131 memoirs on various subjects before 1883.

Comparatively little change took place in the Botanic Garden during these years. J. Stratton, who had been made Curator under Henslow, after Murray's death in 1850, was succeeded in 1864 by C. Mudd, who held the office for fifteen years, till his death in 1879. Under his management the rock garden was laid out in 1867, a new departure which was very successful, the garden being considered at the time the most remarkable in England. About the same time the Long Fern House was erected and made the centre of the collection of ferns which became so noted a feature of the garden, and which indeed remains still one of the principal collections.

Lindley

As we have seen Lindley occupied the Chair of Botany at University College, London, till 1861, when he was succeeded by Professor Daniel Oliver, better known for his work at Kew, to which we have already called attention. He resigned his Professorship in 1888.

Bentley

At King's College, London, Henfrey was succeeded in 1859 by Robert Bentley, a botanist who was better known by his writings on medical and pharmaceutical subjects. He was born at Hitchin in 1821, and was educated at King's College and at the School of Pharmacy in Bloomsbury, devoting himself subsequently to medicine. He became M.R.C.S. in 1847, and was soon made Lecturer on Botany at the London Hospital Medical School. He had a distinguished career as a student at the School of Pharmacy of the Pharmaceutical Society of Great Britain, where he succeeded Anthony Todd Thompson as Professor of Botany and Pharmacy. He retained both his Chairs till near the end of his life, resigning that at King's College in 1887 and that at the School of Pharmacy in 1888. He lived only a few years after his retirement, passing away in 1893.

Bentley was not a great writer, but he contributed to literature in collaboration with Trimen a volume on *Medicinal Plants*, which has since been the most widely-read book upon the subject. In 1861 he published a *Manual of Botany* for the use of his students, which was for long a most popular text-book. It passed through several editions before his death, the last one being edited by Groves, his successor at King's College. The book. still

under Bentley's name, was remodelled, and in the main re-written, by the present author, who succeeded to the Chair of Botany at the School of Pharmacy in 1888.

It made for itself a great reputation in Bentley's lifetime, when text-books were far from numerous, its chief rivals being those of Henfrey, and Hutton Balfour.

Bentley for many years edited the *Pharmaceutical Journal*, and was responsible for the 1885 edition of the *British Pharmacopœia*, in collaboration with his colleague, John Attfield.

Chelsea Physic Garden: Bagshaw Ward

During the period under consideration the decadence of Chelsea went on, though not without a check. In 1862 the Apothecaries' Company set apart a sum of £700 for the improvement of the garden, a vote which brought prominently on the scene a noted member who had been Master of the Company, and who had shown his interest in educational programme by conducting the examination for seventeen years. This was Nathaniel Bagshaw Ward, one of the most accomplished amateur botanists of the day. The son of a doctor in the East End of London he had in early life travelled in the West Indies, where the wonders of tropical vegetation determined him to become a botanist. On his return he became associated with the work at Chelsea, then under the direction of Thomas Wheeler, and thenceforward he combined the pursuit of botany with the practice of medicine, in which he had qualified. His principal achievement was the discovery of the method of cultivating plants in closed cases under suitable conditions, a discovery dating back to 1836. The utility of the "Wardian Case" was strikingly exemplified by Fortune, who brought over from China numerous living plants by its means. In one of his voyages out of 250 plants put into the cases by him in China, only 35 died during the voyage—a striking contrast to the transport of earlier times, for in 1819 it was stated in the *Transactions* of the Horticultural Society that it was rare then for more than one plant in a thousand to survive the journey. Their practical value was seen in the transport by Fortune of 20,000 tea plants from Shanghai to the Himalayas, and in the fact that by their means the Cinchona plant, a native of South America, was established in India.

Ward was all his life a faithful friend to Chelsea. In the administration of the funds raised in 1862 he was one of the leading

spirits. The Garden was placed in a better condition, hot-house plants were again to be found in the houses, extensive alterations were made in the open, especial care being given to the development of a fine collection of medicinal plants. Indeed the whole garden underwent a process of renovation which brought it again into prominence as a school of botany as well as a beautiful place of resort.

Ward lived to an honoured old age, the last years of his life being spent in retirement at Clapham. He died in 1868 in his seventy-eighth year.

In 1862 the Herbarium was presented to the Trustees of the British Museum. It was a very valuable collection, both from its constituent plants and from its historical associations. It consisted really of three separate herbaria, which had been brought together at different times. The first and largest of these was the original herbarium of John Ray in nineteen thin quarto fascicles, which contained his type species of the *Synopsis*. No doubt the timely transfer saved them from utter destruction, for the buildings at Chelsea were participating in the general decay.

Ray's herbarium had passed at his death into the hands of Samuel Dale, who had added to it his own collection. He left the whole to the Apothecaries' Society at his death in 1739. The third constituent was the extensive herbarium of Isaac Rand, one of the early Chelsea worthies. To these as a nucleus had been added the collections of Sloane, Sherard, Petiver, and others, making it as rich in associations as in material. The whole collection passed into the care of the Botanical Department of the British Museum, then under the administration of Carruthers as Keeper.

In 1866 Dr. Hooker resigned the examinership for prizes, and was succeeded by the Rev. Miles Berkeley. It may be noted here that among the names of those who were successful candidates in these examinations occur those of Jenner, Huxley, Maxwell Masters, Trimen, and Bastian.

The management of the garden after Lindley's departure came into the hands of Thomas Moore, who endeavoured to develop it as a centre for the cultivation of medical botany, and to render it more extensively serviceable to students of medicine. In this he achieved a certain success, but the palmy days of the last century had passed away beyond hope of recovery.

In 1870 and the succeeding years a great change in the appearance of the garden was brought about by the construction of the

Embankment along the northern bank of the Thames, when the Metropolitan Board of Works acquired the water frontage of the Society's land.

In 1876 the gardens were thrown open to female students, and prizes were founded for them in 1877, so that they were put upon exactly the same footing as medical students. The first examination was held in June 1878.

The Horticultural Society were still hampered by their financial difficulties, and were compelled to rely on horticultural shows as a source of revenue, so that their enterprise became more and more horticultural and less and less botanical. This financial pressure lasted up to 1887, and their usefulness was materially impaired during the whole period.

The same difficulties beset the gardens of the Royal Botanic Society in Regent's Park. Efforts were made to bring them forward as a convenient place of study for medical students, lectures being delivered there in the early mornings during the summer, and to a certain point these were successful. They had, however, little influence on the progress of botany.

J. J. Bennett

The terrible loss which was the immediate consequence of the death of Robert Brown in 1858 brought into prominence one of his friends and helpers who with great modesty had long been content to occupy a position which involved great work and brought with it but little fame or even recognition. John Joseph Bennett was born in 1801, and after receiving a private education became like so many botanists a student of medicine. During his young days when he was at Middlesex Hospital he formed a friendship with J. E. Gray, the son of the author of the *Natural Arrangement of Plants*, which we have seen was the first British Flora arranged on the Natural system. While still a young man he became associated with Robert Brown, laying the foundation of a life-long friendship. When the Banksian herbarium was transferred to the British Museum and Brown made Keeper of the Department, Bennett accompanied him as his assistant, and at Brown's death he succeeded him as Keeper. He had been made a Fellow of the Royal Society in 1841.

Bennett was perhaps best known as the Secretary of the Linnean Society, a post he held for twenty years from 1840. His labours there fell into a memorable period, closing soon after the

appearance of the *Origin of Species*. Much of the success that then attended the Society was due to the capacity and energy of the Secretary.

At Brown's death Bennett's position at the British Museum was imperilled, for strong efforts were made to transfer the Banksian Collection to Kew. They were, however, unsuccessful, and Bennett succeeded to the Keepership as we have said. He retired from Government service in 1870, and died in 1875. He was succeeded as Keeper by Carruthers, the palæophytologist.

Bennett was an administrator rather than a writer. He contributed, however, to literature, his chief work being his share in the preparation of Horsfield's *Plantæ Javanicæ rariores*, 1838-52.

H. C. Watson

The year 1881 saw the death of another botanist who had spent a long life in unobtrusively working for the development of the science. Hewett Cottrell Watson was born in 1804, and, after a preliminary period of study at the University of Edinburgh, settled down in 1833 at Thames Ditton. He derived his love of botany at an early age from Dr. Stanley, the well-known Bishop of Norwich. His work was mainly confined to England, but in 1842 he was responsible for a *Flora of the Azores*, based upon his personal exploration as botanist to the "*Styx*," which was sent out to conduct a survey of the archipelago.

Watson was mainly instrumental in drawing up the *London Catalogue of British Plants* in 1844. This catalogue long held its own as an authoritative presentation of the plants of the British Flora. His most important work was the *Cybele Britannica*, which appeared in four volumes between 1847 and 1859 with a supplement in 1860. It was a treatise on plant distribution, and grouped all the plants of the country according to their habitats, their vertical range, their historical origin, and their type of distribution.

The series of his works was completed by the *Topographical Botany* of 1873-74, which gave local and personal records of British plants traced through the different districts into which he had divided the country in the *Cybele*.

Watson's ideas had gone on Darwinian lines for some years before the appearance of the *Origin of Species*. In this work Darwin acknowledged "deep obligation" to him for "assistance of all kinds."

Newbould

Another distinguished amateur was the Rev. W. W. Newbould, a friend of Babington, and like him a pupil of Henslow. More unobtrusive even than Watson he was always the helper of other workers, having a very complete acquaintance with the British Flora, and being a recognised authority on the Rubi. He published nothing of any value, preferring the life of a country clergyman to the exploits of the pen.

Trimen

It must have been observed that as time wore on the strict specialisation of the older botanists gave way in many instances to a more general relation to the science. This was a natural if not a necessary consequence of the widening of its scope with the increase of knowledge. Many of the men of the period just preceding the modern revival were men of this type. Among such must be mentioned Henry Trimen, field-botanist, lecturer, author, official, and finally Curator of the Ceylon Botanic Garden.

Trimen was born at Paddington in Middlesex in 1843, and was educated at King's College School. A naturalist almost from his birth, he devoted his leisure in his schooldays and later to a botanical survey of his native county, in which he was associated with Thiselton-Dyer. The work employed them both for many years, and when completed and published in 1869, took a leading place among local floras. It was something more than a mere flora, for it incorporated the results of the older writers and their more recent followers, and paid particular attention to the question of synonyms. Trimen added to it a careful study of the life and work of the early London botanists.

During the progress of the work his life saw several changes. He passed from school to college, entering the Medical School of King's, graduating, and acting as an Officer of Health. He was for some years after 1867 Lecturer on Botany in the Medical School of St. Mary's Hospital.

About the time of the appearance of the *Flora* he entered the botanical department of the British Museum, and remained there till 1879. During these years he was editor of the *Journal of Botany*, the leading publication dealing with taxonomic questions. It was at this time also that he became associated as we have seen with Professor Bentley in the publication of their great classic,

the *Medicinal Plants*, which has been ever since its appearance a standard authority on Pharmacology in England. It has needed but little correction in the light of subsequent research, and still bears emphatic witness to the accuracy and careful research of its two distinguished authors.

But Trimen was too much the ardent naturalist to rest content with museum work. Its necessary restraints and limitations were irksome, and he was eager for the freedom of the open air. He accepted the Directorship of the Royal Botanic Garden at Peradeniya, Ceylon, and left England in 1879. His administration was very successful, and he led a happy and useful life there till 1896, when his health failed, and he retired from active service.

Trimen was a man of large sympathies and broad outlook; he took exclusively neither the official nor the scientific side of his duties at the Garden, but gave earnest attention also to the economic problems which tropical agriculture presented. But his scientific work was of a high order, his studies being directed towards the preparation of a *Flora of Ceylon*, and the elucidations of the problems in geographical distribution which it presents. His administration of the Garden was such as to call forth encomiums from both British and foreign men of science. Unhappily his health broke down before he could complete his *Flora*, three volumes of which appeared between 1893 and 1895. He worked at it till his death, which occurred in 1896. The Handbook was completed four or five years later by Sir J. D. Hooker.

Trimen's scientific attainments were recognised by the Royal Society who conferred on him their Fellowship in 1888.

Masters

Maxwell Tylden Masters was another well-known figure of this period. Born in 1833 he was educated at King's College, London, under Edward Forbes, and was a pupil of Lindley at Chelsea. He subsequently studied at St. Andrews. He had some experience of academic life, having been appointed by Daubeny Sub-Curator of the Fielding Herbarium at Oxford as soon as it had been acquired by the University. In 1854 he was a candidate for the Chair of Botany at King's College, when Henfrey was elected, and not being successful he went into medical practice at Peckham. He was Lecturer on Botany at St. George's Hospital Medical School from 1855 to 1868. In the early part of his life he was a great student of teratology, and wrote a very valuable treatise on the

subject, which was published by the Ray Society in 1869. He did a good deal of literary and scientific work, being editor of the *Gardener's Chronicle* for many years after Lindley's death in 1865, and contributing monographs to various Floras. Among these may be mentioned the account of the Malvaceæ and of the Passifloreæ in Oliver's *Flora of Tropical Africa*, and the Restiaceæ in the supplement to De Candolle's *Prodromus* in 1878. He contributed also to Hooker's *Flora of British India*, to his edition of Harvey's *South African Plants*, and to Thiselton-Dyer's *Flora Capensis*. He edited the 1870 and 1878 editions of Henfrey's *Elementary Course of Botany*. His work was recognised by his being made a Fellow of the Royal Society in 1870, and a corresponding member of the Institute of France in 1888. He died in 1907.

CHAPTER LI

PALÆOPHYTOLOGY FROM 1860 TO 1880

THE work of the earlier writers was carried forward by their successors with even greater distinction. Among the latter the name of one great worker stands out conspicuously among many others, one who became the best-known English authority upon the plants of the Coal Measures.

William Crawford Williamson was born in 1816. In his early life though an ardent student of Natural History he gave little promise of the eminence to which he afterwards attained. His bent, however, even in his youth was towards the floras of the past, and he contributed several papers to the work of Lindley and Hutton, which has already been mentioned. At the age of nineteen he became Curator of the Manchester Natural History Museum. Subsequently he engaged in medical practice and scientific lecturing. In 1855 he was Surgeon to the Manchester Institute for Diseases of the Ear, and became its Consulting Surgeon in 1870. Even till his seventieth year he continued to engage in professional medical work.

Williamson will always be associated with the Owens College (now the Victoria University) of Manchester. In 1851 he was made its first Professor of Natural History, Anatomy, and Physiology. In 1872 the last two sections were split off from the duties of his Chair, and in 1880 the zoology also was given to a separate professor, leaving him in charge of botany only.

In 1854 he was made a Fellow of the Royal Society.

As we have said, his earliest work, carried out when he was little more than a lad, took the form of contributions to Lindley and Hutton, and was published from 1833 to 1837. It was illustrated by thirty-two plates drawn by himself. Throughout his life he devoted himself to similar problems in the main, though he did not a little general geological work up to 1870.

In 1851 he published an important memoir on Sternbergia, which afterwards proved to be the stem of Cordaites, a Gymnospermous plant. But when he really settled down to fossil work he showed

himself fascinated by the plants of the Coal Measures, of which he became an enthusiastic student. Our knowledge of at least four large groups was materially added to by his researches.

Williamson's method of work was largely peculiar to himself. He based it on sections, the preparation of which from fossils owes much to him. His memoirs are largely minute descriptions of his own drawings from such sections, drawings prepared with wonderful skill and accuracy of detail.

The first group with which his name may be associated is the Calamites, his researches in which made him acquainted with the leaders of the French school, Grand 'Eury in particular. He contested, however, the views which Brongniart had made popular in France, and taught that the Calamites constituted essentially one large group of plants, from which he held that the types of modern Coniferæ and Equisetaceæ sprang. He contested with much force Brongniart's argument that the occurrence of secondary thickening in some Calamite stems involved the separation of a large group from the rest, and its inclusion among Gymnosperms.

In the course of his work on this group he demonstrated that it included some heterosporous forms.

His investigation of the group was very extensive; indeed, he studied all parts of the plants—stems, roots, and fructifications.

The second group to which he gave much thought was the one which he called Asterophyllites, but which is now known as the Sphenophyllaceæ. He worked out the anatomy and the fructification of two species of these plants, and again demonstrated the existence of secondary thickening in Cryptogams.

While Binney may be said to have discovered the Lyginodendreæ in 1866, Williamson gave much attention to the group, and in his later years he elucidated their structure in collaboration with Dr. Scott, then Keeper of the Jodrell Laboratory at Kew, but this work falls more legitimately into the next period.

The last group with which we may associate his name is that of the Lepidodendreæ. Here again he found himself compelled to join issue with Brongniart and the French school. It was the same battle as he had fought over the Calamites, and it ended in both cases in Williamson's favour, and by the time of his death his views had been accepted by all, even his opponents coming over to his side.

This burning question—the existence or non-existence of secondary thickening in Cryptogams—was of the highest importance in

settling some of the details of phylogeny, and it was a point which Williamson took up with perhaps more enthusiasm than any other.

Of his Lepidodendreæ work apart from it, it may be said he described the anatomy of ten forms, proved Lepidodendron to have been a heterosporous plant, and did more than any one else to make known the structure of the subterranean parts.

Though doing so much research on these four large groups, he carried out many other investigations and researches on similar lines. From 1870 onwards till his death in 1895 his contributions to the *Philosophical Transactions* form one of their most important features.

Williamson's work was in some respects imperfect. He relied on his own judgment entirely as to his fossils, declining to read up any literature till he had completed his study in the particular case he was dealing with. Though his work was thus original in the true sense it was somewhat narrow. It lacked the method, too, which is developed by personal academic training or laboratory experience. Williamson disliked speculation and dogmatism—a good quality up to a certain point, but it took from him any share in the promulgation of scientific theory.

Binney—Carruthers

Two other workers during these two decades were Binney and Carruthers. Of Binney's earlier work we have already spoken. We have also mentioned his discovery of Lyginodendron in 1866. About the same time he was actively investigating certain problems connected with the Calamites, and in 1870 he described the fructification of Sphenophyllum, known then and for some years subsequently as Bowmanites.

Carruthers was Keeper of the Botanical Department in the British Museum after the death of Bennett till 1895. In palæobotany he worked over a wide area; from 1867 to 1869 he was engaged in investigations on the Gymnosperms, dealing particularly with various forms of fruit from the secondary rocks; in 1872 he determined Dawson's fossil Prototaxites to be an Alga related to the larger Siphoneæ, and renamed it Nematophycus. Like Williamson, he took up the Calamarieæ, and he determined the fructification, known until 1867 as Calamostachys, to belong to a Calamite. In 1869 he described the structure of *Lepidodendron selaginoides*. In 1868 he founded the genus Bennettites for certain Cycadean stems occurring in the

oölitic and lower cretaceous formations. He described the structure of the stem, and gave a very full account of the fructification, or rather of what he took to be the female flower. Nothing more was discovered of it for some years, indeed, doubt was cast upon the supposed relations between the flowers and the stem. However, subsequent observers, particularly Solms-Laubach and Wieland, completely vindicated Carruthers.

CHAPTER LII

CONTEMPORARY BOTANY IN SCOTLAND AND IRELAND

On the death of Arnott in 1868 his place was filled by the election of Alexander Dickson, who had been Harvey's successor at Dublin two years before, and had held also the Chair of Botany at the new Royal College of Science there for a year. Dickson had had a varied experience of University life. He was born at Edinburgh in 1836, and graduated as M.D. in the University there in 1860. The illness of Professor Dickie called him to Aberdeen, where he lectured with much success for several years. He was called to Dublin on the death of Harvey in 1866. He succeeded Professor Hutton Balfour at Edinburgh in 1879.

Dickson was best known as a highly successful teacher. He wrote numerous papers in leading botanical journals, mainly upon morphological subjects, embryogeny in particular possessing a great fascination for him.

The years of this period at Edinburgh were uneventful. The botanical interests of the University were in the hands of Professor Hutton Balfour.

The death of Harvey in 1866 was a great blow to the progress of botany in the University of Dublin. His task in the rearrangement of the Herbarium was far from complete and the cessation of his activity was severely felt. Dr. Alexander Dickson was elected his successor in the Chair of Botany, but no appointment was made to the Keepership of the Herbarium. He only held the Professorship for two years, when he removed to Glasgow and Percival Wright was appointed to succeed him. Wright was a naturalist of much versatility. He was born in Dublin in 1834 and educated at Trinity College, Dublin, where his tastes were formed and developed under Professor G. J. Allman. His early contributions to science dealt chiefly with the flora and fauna of the south and west of Ireland, indeed he was the first to call attention to the living fauna of Irish caves. In 1857 he graduated and was appointed Director of the Museum in Trinity College. After a time of assiduous application to medical work, in which he gained considerable reputation as an oculist, he took up again

the study of botany, and in 1865 he published some work on the flora of the Aran Islands. In the incapacity of Professor Harvey through illness in that year Wright acted as his deputy. During the short professorship of Dickson, Wright was engaged in explorations abroad, and on his return was elected to the Chair of Botany just then vacant. The Keepership of the Herbarium was given to him a little later, and the greater part of his time during his tenure of the Chair was devoted to it. In 1877 he began the publication of a series of memoirs on the structure and development of various species of Algæ, which considerably enhanced his reputation. He continued this work till he was called upon to co-operate in the colossal labour of arranging and reporting on the results of the *Challenger* expedition.

In 1894 and 1895 Wright was occupied in botanical exploration in the Pyrenees and in Northern Africa, in the course of which he made considerable additions to the Herbarium.

He held his Chair till the end of the century, resigning it in 1904 when he was succeeded by the present Professor, Dr. H. H. Dixon, who had been his assistant for ten years. Though he contributed only in a small degree to the literature of the science, he was a teacher of high order, a careful custodian of the Herbarium, and a sympathetic friend of all his younger colleagues and students.

The establishment of the Royal College of Science at Dublin in 1867 was coincident with the appointment to the Chair of Botany, vacant through the death of Harvey in the previous year, of Dr. Alexander Dickson, who, however, only held it a little more than a year, when, as we have seen, he removed to Glasgow. Dr. Dickson was thus for a short time in charge of both the Dublin Chairs as Harvey had been before him. With his departure this plurality of offices came to an end. Percival Wright took the Professorship at Trinity College, while Wyville Thomson of *Challenger* fame occupied the Chair at the Royal College. Thomson was, however, attached much more strongly to Zoology than to Botany, and in 1870 he was appointed Professor of Natural History at Edinburgh. The vacancy at Dublin was filled by the appointment of Professor (afterwards Sir William) Thiselton-Dyer, to whose activities a few years later botanical science in England owes so much, as we shall see, in other connections. He only held the Professorship for two years, being succeeded in 1872 by W. R. McNab. The new Professor came of a botanical stock; his father and grandfather between them held the Curatorship of the Edinburgh Gardens from 1810 till the death of the younger in 1878.

He had been educated at Edinburgh University, where he graduated as M.D. in 1866. In 1870 he left Edinburgh to become Professor of Natural History at the Royal Agricultural College at Cirencester. It is to be remarked that while holding this latter post he was the first to introduce into England the methods which Sachs had brought into botanical study in Germany.

In 1877 the gardens at Glasnevin entered on the third period of their history, when by special Act of Parliament the Royal Dublin Society completed the transfer of the control of their Garden, Museum, and School of Art to the Science and Art Department. Two years later Dr. Moore died, having been Superintendent for more than forty years. He was succeeded by his son, now Sir Frederick Moore. In 1880 McNab was appointed Scientific Superintendent and Referee—an office abolished at his death in 1889.

CHAPTER LIII

THE COMING OF THE LABORATORY

ANOTHER striking feature of these two remarkable decades was the breaking down of the isolation of England in botanical science. True, this isolation had not been complete, but during and after the Napoleonic wars intercourse between scientific men had been greatly interfered with, partly by difficulties of inter-communication, partly by national prejudice. As we have seen, efforts were not wanting to overcome the feelings of national hostility which were a bar to scientific intercourse. Banks had set his face against the confiscation of scientific material during the war, Hooker had given a hearty welcome to foreign botanists both at Glasgow and at Kew. Still a want of cordial relationship and intercourse was to a certain extent observable under the influence of the international complications, and the course of scientific thought flowed consequently in somewhat different streams on the two sides of the Channel.

We cannot here trace out the course of development that Germany and France had witnessed. The study of vegetable morphology and of the microscopic anatomy of plants had been developed by a long series of workers in both countries; Mirbel in France, and K. Sprengel in Germany had revived the study, and conspicuous among those who followed them were Moldenhawer, Unger, Von Mohl, Naegeli, Tulasne, and Thuret. More recently the great work of Hofmeister on the Higher Cryptogamia had appeared, a work which was the principal anatomical production of the fifties, and which did probably more than any other to stimulate anatomical study and to point to the phylogenetic relationship of the whole vegetable kingdom. An English translation of Hofmeister's book which appeared in 1862 helped very materially to prepare the way for the developments of the rest of the century.

Physiology had attracted more attention in England. Indeed, most of its early progress was due to English workers. We have noticed the researches of Hales, of Hope, of Andrew Knight, of Daubeny, and later of Darwin, all of whom worked so carefully at

many of its problems. With the beginning of the sixties Germany made great strides in this field under the influence of the teaching and research of Sachs and of De Bary. The work of the latter writer in the study of Fungi brought him a great reputation as an anatomist and led him to important conclusions on the classification of this, till then, little known group.

The writings of Sachs and of De Bary attracted as much attention in England as in Germany and paved the way to a much closer association between the botanists of both countries than had existed for many years. A movement was consequently set up which revolutionised especially histological study on this side of the Channel, and which rendered possible the enormous development of botanical science and research which took place during the last two decades of the century.

No doubt the great attention which the English botanists of the early part of the century had given to taxonomic questions and the problems of geographical botany was largely the outcome of the growth and expansion of the Colonial and Indian empire during those years. This expansion was so notable a feature of the time that it almost obsessed the minds of the scientific workers who saw strange floras opened to them, full of deep interest and presenting problems of the greatest importance, both botanical and geographical. It cannot be wondered at that the study of histology took but a subordinate place with them, though, as Robert Brown's classical researches show, it was recognised to have its place, and that no trifling one, in the field of science.

But in these two decades the balance began to be rectified. Not that it was a severe recoil; we must recognise in addition to the forces so far noted, a new influence which came to be exerted by one of the most distinguished exponents of biological science that had so far appeared. Great as was the work of Darwin and wonderful as was the revolution in thought which it brought about, it is certain that it owed not a little of its success to the brilliance of the advocacy which it received at the hands of several of his distinguished contemporaries. Unquestionably the first place here must be given to Hooker, as we have already seen, but a very prominent part in the evolutionary movement that was then set up was played by Huxley, who, though not a Darwinian, was probably the most earnest and successful exponent of the dogma of evolution. Though not specially a botanist he gave a greater impetus than almost any other Englishman to the remarkable development of botanical science that marked these years. It is

a little strange to read that he did not consider himself a naturalist; perhaps he was not, according to the old conception, which gave the appellation principally to workers in the field, but at any rate he gave the term a new definition and raised his readers to a new and larger meaning of its scope. He said: "There was very little of the genuine naturalist in me; I never collected anything, and species work was a burden to me. What I cared for was the architectural and engineering part of the business; the working out of the wonderful unity of plan in the thousands and thousands of diverse living constructions, and the modification of similar apparatus to serve diverse ends." Notwithstanding his repudiation of the name, we may very well admit to-day that he has here put forward the ideal conception of a naturalist.

Born in 1825 and educated privately, Huxley devoted his early years to medical work, but was soon diverted from its profession to the larger field of biology, and took up, after a long sea voyage in Australasia, practical research in zoology. It was not long before he was recognised as the leading English authority in this science. After a few years he was appointed to a professorial post at the institution shortly afterwards known as the Royal School of Mines, whence developed that close connection with the Science and Art Department at South Kensington that was maintained during the remainder of his life.

It is, however, with Huxley's influence on the trend of scientific thought rather than with his personal triumphs in another field than botany that we are concerned here. We may quote some words of one of his most distinguished pupils, Sir Michael Foster, bearing testimony to the immense importance of the work he did: [1] "From the very first Huxley had felt it as a duty laid upon him to expound by mouth and by pen the teachings of science in general, and of biological science in particular, to that large part of the world which lay outside science, knowing little of it, and caring less for it; for there came to him very early the conviction that science was not merely the study of the few, for the sake of the intellectual appreciation of the pursuit or the material benefits of the applications, but a thing to be known, and so far as may be, understood of all men as a sure guide for human life . . . he at once saw the far-reaching value of the lesson in evolution so forcibly expounded in the 'Origin of Species by Natural Selection' . . . and he became known far outside the narrow circle of scientific workers as the powerful champion of what soon came

[1] *Proc. Roy. Soc.*, 41, 1895-96.

to be called the Darwinian doctrine. . . . The name of Huxley . . . became rapidly to be quoted among the people as the name of a leader of men in science."

Huxley's ardent devotion to biological science and his keen desire for its wider dissemination led him to inaugurate an energetic educational policy. In 1872 his teaching was transferred from the School of Mines to South Kensington, where he organised lectures for selected teachers of the classes held under the Science and Art Department. He so arranged the work as to make it a model of instruction in the general principles of biology. He gave a lecture each morning during the duration of the class, and his students then worked in his laboratory during the rest of the day under the guidance of able demonstrators. His first helpers were Foster, Ray Lankester, and Rutherford, and among those who came later were Thiselton-Dyer, Martin, and Vines—all biologists who attained great eminence in later years. This course, first given in 1872, but continued year by year, sometimes under other direction, for long afterwards became a pattern for biological instruction in England, and in the main was the basis of the practical teaching given in so many centres at the present day. From it sprang the well-known laboratory handbook that bears the names of Huxley and Martin, a work which Huxley originally projected to supplement the *Forms of Animal Life* of Professor Rolleston.

It was inevitable that this powerful influence should make itself felt not only in the broad field of biology, but in the more circumscribed area of botany. Coming as it did side by side with the dawning of the influence of the German school, especially of the writings of Hofmeister and the teaching of Sachs, it led up to the most startling changes, for it prepared the way for a total revolution in the methods of botanical study. After prolonged effort on the part of many of the younger men, most of whom had come under Huxley's personal charm, the laboratory came to loom large among the appliances of the botanist. As the sphere of the garden had been largely superseded by that of the herbarium, it now became the turn of the latter to fall back from its pre-eminence, and to make way for the new methods. Hitherto there had been no such institution in England as the botanical laboratory; the individual botanists who had pursued research, Hales, Knight, Darwin, and others, had been obliged to depend upon their private resources, and to work at their own charges, and there had been consequently little oppor-

tunity for any particular development. The wonder is not that no more had been done—rather that with so few appliances and in the absence of all organisation the workers had achieved so much.

The astonishing development in the field of botany of which we have been speaking was largely due to the perspicacity and energy of Thiselton-Dyer, who caught Huxley's enthusiasm, and applied himself to the new propaganda after the manner of the master. He was by no means new to botany, for he had been educated at King's College, London, under Bentley, and had subsequently had a distinguished career at Christchurch, Oxford. It had indeed been anticipated there that he would be Daubeny's successor in the Sherardian Chair, but unhappily the vacancy came before he was of sufficient academic standing to fill it. While still a boy he had been associated with Trimen in those explorations to which we have already alluded, and which culminated in 1869 in the appearance of the *Flora of Middlesex*—a book that soon made its mark. As we have seen, it was a valuable piece of work, allying the recent flora with that of much earlier times, and identifying all the plants found by the mediæval herbalists in the neighbourhood of London. On leaving Oxford in 1868, Thiselton-Dyer had taken the Chair of Natural History at the Royal Agricultural College, Cirencester, where he organised thorough courses of study on the morphology, taxonomy, and physiology of agricultural plants, dealing incidentally with the problems of pathology. In 1869 he associated himself with Professor A. H. Church in the production of a revised text-book for his students which served as a useful introduction to the study of vegetable physiology and agricultural chemistry so far as they were understood at the time. In 1870 he removed to Dublin, where he followed Wyville Thomson in the Chair of Botany at the Royal College of Science. Here he was untrammelled by the requirements of any curriculum, and accordingly mapped out an extended course of lectures, in which he treated, in as great detail as time would allow, every principal group in the vegetable kingdom. But he was handicapped by the fact that there was no provision for practical work of any sort, and had to make his illustrations depend entirely on diagrams, which were drawn for the most part under his personal direction in the Government School.

After two years he left Ireland to accept the Professorship of Botany at the Royal Horticultural Society in London, and after a short further interval he became associated with Kew, then under the direction of Sir Joseph (then Dr.) Hooker.

He was thus on the spot in 1872, and in touch with Donelly and the other leaders of the Science and Art Department when Huxley started his first noteworthy course in that memorable year. It may be imagined how the new departure appealed to him, and how he saw for the first time some hope of the realisation of his own aspirations in the same direction. He was associated with Huxley in 1874 as his senior demonstrator in his second course, and as years went on he became more and more the leader in the new botanical teaching.

Before setting out in detail the main features of his work in connection with South Kensington we may pause to inquire what was the state of botanical teaching generally in 1872, and how far it had developed since the days of Martyn. In a letter to the writer Sir William says: "In the seventies Botany was only taught in Universities and Colleges as part of the medical curriculum, and was only regarded as an introduction to Materia Medica. There was a literature of the period which treated of 'Medical Botany.' The courses of lectures and text-books (Balfour, Henfrey, Bentley) were devoted almost exclusively to the morphology and taxonomy of Phanerogams. The morphology based on the French School had a certain attractiveness, and I think was in advance of current teaching in comparative anatomy, which was purely descriptive. . . . The taxonomic side was rather a stumbling block to the ordinary medical student. But it had an attraction for a few, and the medical schools supplied a training for many of our systematists. A good feature of the teaching was that it was usually well supplied with fresh specimens, and students in London had the run of the Botanic Gardens in the Regent's Park and at Chelsea. There were usually one or two excursions in the summer into the country for field-collecting. But so far as I know there was no laboratory work. The development of histology held out some promise of a wider scope. The works of Von Mohl, Schwann, Braun, and Schleiden were translated. Henfrey would probably have gone far if he had not died young. Berkeley is a remarkable and isolated figure. He was in touch with the French cryptogamic botanists, and would talk of sitting on the Boulevard in Paris, talking to Montagne. . . . At the time I shared the general belief that the manipulative difficulties were so great in demonstrating the things to be seen in text-books that only men like Hofmeister could accomplish it. I was shaken in this belief at the British Association in Edinburgh in 1871, when Prof. A. Dickson had a remarkable exhibit illustrating

monocotyledonous embryos. He was, I think, the first of our botanists to get an inspiration in original work from Germany."

There seems thus to have been a deep-rooted conservatism of method lasting since the days of the early systematists. But the recognition of evolutionary progress in Nature showed that the old field was too narrow, and brought with it the necessity of a considerable extension, involving a more complete survey of the whole field of the Vegetable Kingdom. The new teaching did not therefore abolish the old or obliterate the lines on which it had proceeded; it aimed to supplement rather than to supplant, though perhaps the enthusiasm with which it was greeted by teachers and students alike tended to obscure the older taxonomic work, and put it for the moment into the background. This was, however, but a transitory phase; the teaching of the great taxonomists from Robert Brown onwards, and the magnificent work they had achieved, could not be more than temporarily obscured even by the attractions of the new departure.

Meantime great developments of the latter were at hand. In 1873 Huxley broke down in health and was unable to repeat his course. Thiselton-Dyer was asked to step into the breach and to take the direction of things pending Huxley's recovery. In this way he became associated with the work of the Department in London.

In the conduct of the course he followed the general scheme that had been marked out by Huxley, while he organised the details on independent lines. In the work he was able to renew his association with Oxford, having Professor Lawson, Daubeny's successor, as one of his demonstrators.

This course of 1873, taken up under some disadvantage, was a notable one in the history of botany in England. Quoting from the same letter as before we find Sir William describing some of its features as follows: "The difficulties were enormous. The first was that of keeping up a continuous supply of material; but we had Kew to draw upon, and a great number of helpful friends. Archer in Dublin sent us fresh-water Algæ, a banker at Margate, marine Algæ; Ransome of Nottingham and De Bary (through Lankester), Æthalium; H. C. Watson, Pilularia, etc. The worst difficulty was to make some of our own ground; Lawson and I were generally up half the night rehearsing the demonstrations for the following day. However, we soon worked the class up to a pitch of enthusiasm, and this helped us enormously. I was perfectly frank in explaining our own inexperience and

enlisting its help. The more expert men often had good luck in getting things out. The upshot was that we succeeded in showing shoals of things that had never been seen in England before. News of what was going on soon got about, and though we were flattered we were a good deal bothered by visitors. No one had ever seen in this country an active plasmodium of a Myxomycete, and Klein asked to be telegraphed for when it began to work. W. Kitchen Parker spent most of his time in the laboratory. Sir Edward Poynter came to see antherozoids, and we gratified him with those of *Chara* under a one-twelfth immersion. Gymnosperms gave us most trouble. I was very keen to demonstrate what Hofmeister had done and to trace the outcome and fate of the megaspore from the Ferns upwards. It would have seemed hopeless if Casimir de Candolle had not come to England after working with Strasburger, and brought a number of preparations with him. He showed me that the difficulties were not insuperable. This was before the days of microtomes, or even embedding. . . . However the ground of the new teaching was broken once for all."

In 1875 Thiselton-Dyer organised a more leisurely course of botany on similar lines, which extended over eight weeks. In this he was associated with Vines, afterwards the leader of botanical study at Cambridge and later at Oxford. The work done during this course laid the foundation for the *Handbook of Practical Botany* of Bower and Vines, which was really based upon it. Among the students who attended these lectures were Marshall Ward, afterwards Professor of Botany at Cambridge, and Hick, ultimately demonstrator to Williamson at Manchester. The former was the most able of the members of the class, and the inspiration he derived from it, with the enthusiasm it evoked in him, determined his career.

Similar work was done in 1876 and again in 1880, and during those years the class-roll contained the names of many who became well known as botanists in later years. Among them was Sir Daniel Morris, while in the ranks of the demonstrators were McNab, Bower, and Hillhouse.

It was just at this juncture that the movement for the study of physiological botany at Kew was being promoted. Thiselton-Dyer, who as we have seen was made Assistant-Director of the Gardens in 1875, played a large part in the launching of the new enterprise. Indeed, it is doubtful if without his enthusiasm the scheme would have materialised which resulted in the establish-

ment there of the Jodrell Laboratory. Though it owed its inception to private munificence, it was destined to become recognised as one of the most important scientific features of Kew, and to play a very important part in the development of research during the remainder of the century. The names of many who worked there rank among the most eminent scientific men of England; the results obtained there were published in the foremost scientific journals of the time; no less than six of the workers obtained the honour of the award of medals by the Royal Society. It would be tedious to mention every piece of research that came from the Jodrell, but notice may be taken here of many. In Vegetable Physiology we have Professor Tyndall's work on the organisms of putrefaction; Professor Burdon-Sanderson's researches on the electromotive properties of the sensitive leaves of *Dionæa;* Schunck's work on chlorophyll; Horace Brown's researches into the problems of photosynthesis and other metabolic phenomena; in Vegetable Morphology, Bower's researches into the relations of the Gnetaceæ, and the Ferns and other Vascular Cryptogams, and his observations on the phenomena of apospory; in Vegetable Anatomy, the researches of Gardiner on the continuity of protoplasm in vegetable tissues; those of Scott, Bower, Gwynne-Vaughan and others into the construction of the axes of various groups, and the classic work of Williamson and Scott, continued by Scott after the lamented decease of Williamson—work which threw so much light on the structure and affinities of many fossil forms. It is perhaps a little invidious to single out even these among many others; indeed, not less than 118 memoirs of importance were contributed to science by thirty-six workers between the years 1875 and 1900, while six investigators were awarded the Royal Medal of the Royal Society.

Thiselton-Dyer exerted a potent influence in yet another field. The magnificent results that had been obtained by the great anatomists and morphologists of Germany had been gathered together and by the masterly hand of Sachs had been embodied in the great *Lehrbuch* which had come from his pen in 1868. This famous treatise was in 1875 in its third edition, while a fourth was in active preparation. In great measure by the influence, and at any rate on the initiative, of Rolleston, then Professor of Comparative Morphology at Oxford, the Clarendon Press was led to consider the desirability of having a translation prepared, so as to be put into the hands of the young students in England while the enthusiasm stirred up by Huxley and by Thiselton-

Dyer was running high, and they were keen to master the results of Continental research.

How great the need for such a work was at the moment may be gathered from glancing at the condition of the English text-books of the day, which was described a little later by McNab, himself an early pioneer of the methods of Sachs and one of the first to introduce them into his classes. "Our text-books had mostly fallen behind the time; the older theories and ideas were still retained, instead of being swept away to make room for new facts or for the more correct interpretation of long known but imperfectly understood phenomena. The illustrations were often defective and frequently inaccurate, and yet descended from text-book to text-book with unfailing regularity. Terms were multiplied needlessly, without any correct appreciation of the facts to be indicated by them; lectures became a mere illustrated botanical glossary; the biology and physiology of plants were almost entirely neglected, and the science rendered as repulsive as possible."

In a state of things as deplorable as this, the clearness and lucidity of Sachs's text-book were a revelation. When the Clarendon Press adopted Rolleston's suggestion, he proposed to them that Thiselton-Dyer should be invited to edit the translation, and the work was accordingly produced under his direction. The actual translation was done by A. W. Bennett, but everything was revised by Thiselton-Dyer, to whom consequently the excellence of the English version must be attributed.

In the light of present-day research with its enormous strides, which limit the reliability of most text-books to a few years, this first edition of Sachs naturally leaves much to be desired, but coming when it did in 1875 its influence was very potent. McNab says of it: "We have a text-book of Botany which the teacher can confidently recommend to the student as being an excellent guide, as giving an extensive and trustworthy account of the present state of botanical science in Europe, and while it indicates the theories and problems at present occupying the attention of botanists, it points them to the subjects which will best repay the original investigator."

It is interesting to note here not only the influence of German thought in England, but also the way in which English ideas were making their way in Germany. The book shows how the work of Darwin was affecting German ideas, for wherever possible, particularly in the second section of the work, the influence of the "Theory of descent" is very evident.

South Kensington and Kew became thus the English centres from which the new teaching was to spread. The Universities of Oxford and Cambridge were very soon affected by it, and both became before long centres from which the influence of the new direction of study was to extend. Of the two, Oxford took the lead. Lawson, who we have seen had succeeded Daubeny in the Sherardian Chair, had been associated with Thiselton-Dyer almost at the outset. He set up at once a new departure at Oxford and, leaving the methods of his predecessor, gave his principal attention to the class teaching of microscopic anatomy and histology. In the summer term of 1873 he gave lectures on structural, systematic, and economic botany, but in the next year developed more fully the biological side. At the time Ray Lankester was at Exeter College and was conducting his work there in Zoology very enthusiastically on the lines of Huxley. During 1875 the two co-operated in starting and carrying on a somewhat elaborate course in General Biology which was repeated during several years till Lawson's departure for India. The work was as arduous as Huxley's own courses at South Kensington; every day during term one or other of them lectured from 10 to 11, and laboratory instruction claimed the time from 11 to 12.30, and from 1.30 to 4. In connection with Lawson's work new laboratories were built in the Gardens, and the old Herbarium refitted as a lecture room.

Somewhat strangely it fell out that the permanent results of this activity at Oxford cannot be compared with those achieved in London nor those which later followed the energy of Vines at Cambridge.

Cambridge, like Oxford, soon fell under the spell of the new methods, and though later than the sister University in starting, after a while surpassed her in enthusiasm for the study, becoming indeed for a time the leading seat of botanical study and influence in England. Under the influence of Huxley's teaching a great revival of biological science was in progress there. Michael Foster, who had been closely associated with the great Master in his pioneer work, had caught the afflatus of his spirit, and was engaged in developing his teaching. Under the auspices of Trinity College, and with the encouragement of Dr. (afterwards Sir George) Humphrey, Professor of Anatomy, and of Coutts Trotter, Tutor and afterwards Vice-Master, he had inaugurated a new school of Biology, and had gathered round him all the leading younger men of the time. Martin, F. M. Balfour, Langley, and many

other prominent men were helping him in the formation of a great department of learning, chiefly on the animal side of biology, and great enthusiasm had been excited. His own lectures on Animal Physiology were attracting from all parts students who were eager to adopt and develop the new methods of anatomical and physiological study. The creation of this atmosphere and the resulting progress on the animal side of biology excited the emulation of leaders in the other sciences, and a great and general revival of study in all these branches set in at the University. Into this environment came an ardent follower of Foster, who ultimately played a leading part in the promotion of the progress of botany in the United Kingdom.

Sydney Howard Vines made his entry into Cambridge life in the Michaelmas term of 1872, after having devoted several years to medical study in London. Originally contemplating a medical career he was led to the pursuit of pure science by the personal influence of Foster and of Thiselton-Dyer, with both of whom he became associated during his undergraduate years, and who had no small share in guiding his career. Attracted to Cambridge mainly by a desire to study animal physiology under Foster, he entered Christ's College, destined to be for so long the scene of his activities. He had already begun to study for a degree in science under the old examining University of London, and he pursued in his early years at Cambridge the course which this involved. At the time of his entry H. Newall Martin, Huxley's friend and collaborator, was Tutor at Christ's College, and Vines naturally came immediately under his influence. During the summer of 1874 the first step was taken on the ladder which led to his eminence as a teacher. Martin secured his assistance in conducting the course in General Biology which Huxley had initiated two years before, and so brought him into the sphere of enthusiasm of which South Kensington was the centre. Then began his association with Thiselton-Dyer, who was acting as Huxley's senior demonstrator, and it developed into a close personal friendship, so that when the more strictly botanical course of 1875 was undertaken, Vines took a considerable share in conducting it, and was thenceforward allied with the new teaching which Thiselton-Dyer had inaugurated. This seems indeed to have been the turning point in his career, for up to this time he had not been specially interested in botany, indeed, in his graduation as B.Sc. at the University of London in 1873, he did not even present the subject. During his early Cambridge course his leanings towards the animal side of

biology were marked by his holding for a short time the position of one of Foster's demonstrators. After his experience with Thiselton-Dyer in 1875 he devoted himself almost entirely to botany, the subject becoming more congenial to him than any other. On his return to Cambridge, under the stimulus of the work at South Kensington and with the keen enthusiasm of Foster in front of him, he determined to essay the development of the science there.

But discouragement met him at the very outset; there were no accessories of any kind available, and he had as a first charge upon his time the duties incident to his graduation. He came out with great distinction in December 1875, the first man of his year. The College was prompt to recognise his merit, and in 1876 he was elected to a Fellowship and appointed a Lecturer in Natural Science.

From this point onwards Vines's Cambridge career was one long-continued struggle for the advance of botanical teaching in the University interrupted only by absences for the purposes of lecturing at South Kensington, or research and study under the great German teachers of the day. The year 1876 saw his first efforts; after conducting in conjunction with Thiselton-Dyer a course in practical botany for Science teachers at South Kensington, he gave his first course of lectures at Cambridge. Modelled in the main upon the South Kensington work, he had the disappointment of not being able to illustrate them practically for want of a laboratory or anything capable of being made a substitute for one. Nevertheless, the course was memorable as marking a new departure. It drew to him the keener spirits among the young men, and particularly F. O. Bower, subsequently the noted morphologist and Professor of Botany at Glasgow.

This first course was the precursor of others during the next academical year, when these lectures became extended over the three terms instead of being confined to the summer. Set free during this part of the year Vines put himself under Sachs at Würzburg, and occupied himself by research into various questions of vegetable physiology. In undergoing this further training he set an example which was followed by many of the botanists who became later his colleagues and pupils at Cambridge.

The next autumn marked another stage in the progress of his enterprise, for a beginning was made of the gradual evolution of a botanical laboratory. Foster had been similarly handicapped at the outset, but temporary provision had been made for him,

though at the moment his equipment left much to be desired. He was full of sympathy with Vines in these early struggles, and he was as keenly desirous as any one that the development of Cambridge science teaching should be on the broadest possible basis. With characteristic generosity he managed to squeeze out sufficient accommodation for a beginning in practical botany, and he put it at Vines's disposal, so that a class in laboratory work might supplement the lectures. This was the foundation of the practical study of botany at Cambridge, a departure which a hard struggle carried on for many years and by many workers led through several stages to the erection of the large and well-equipped Botanical Institute which was completed under Marshall Ward in 1903.

The year 1880 consequently saw Vines established as a teacher in the University, carrying out theoretical and practical training and attracting to himself the best of the scientifically disposed among the undergraduates, as well as others not members of the University, drawn to him by his growing reputation, and sharing his own enthusiasm. In some sense he may be said to have discharged the duties of a Professor though he held only College status, for he instigated and promoted research among such of his pupils as were qualified to conduct it. Among those who gathered round him in these early years besides Bower were Marshall Ward, afterwards Professor, Walter Gardiner, known later through his demonstration of the continuity of the protoplasm of adjoining cells through the cell wall, and Scott, some years later the Honorary Keeper to the Jodrell Laboratory at Kew.

The training in methods of research which Vines received under Sachs led him during these years to conduct an inquiry into the composition of the nitrogenous reserve materials of seeds. He made a very extended analysis of a very large number and was able to classify the proteins they contained after the nomenclature of the time. The chemistry of the group was for the moment very much influenced by the teachings of Kühne, and Vines identified many of those occurring in plants with members of Kühne's groups of animal origin. The work was very laborious and thorough, though the results proved later to need revision in the light of the researches of later chemists and the consequent modification of Kühne's proposals.

Vines was during all this time maintaining and extending his relations with German thought. For parts of 1879 and 1880 he was away from Cambridge, working partly at Strassburg with De Bary and partly at Würzburg with Sachs.

During these early years Vines was confronted with a very difficult task. Apart from Foster and his immediate circle there was very little sympathy with the new departure. Babington was old and feeble and his personal interests were those of a specialist in particular groups. Outside taxonomy he did not care to go, and in his teaching he was content to plod along the old lines laid down by Henslow. Even the magnificent results that had been achieved by the great systematists of the century he passed by as far as his students were concerned. Vines had consequently to fight his battle alone, and gradually to raise a new public opinion. He was hampered, too, by the almost entire absence of facilities for practical work. There was no laboratory at the Botanic Gardens and Foster could spare him but a limited space. There was little available room at the Herbarium, and not till 1881 did Babington place that little at his disposal. In that year, however, he allotted him a small annexe to the Herbarium that had been occupied by the Assistant Curator, so giving him space to accommodate about a dozen workers with the microscope. But for several years that was all.

Hillhouse, an old Bedford boy, who had been educated at Trinity College, and had studied under Vines, was appointed Assistant Curator of the Herbarium by Babington in 1879 before he had finished his academic course. He soon took an active share in the work of teaching, and to some extent reorganised the classes in taxonomy, reviving the botanical excursions which had fallen into abeyance. He also instituted a general course of elementary lectures on the new lines, but could offer his students no facilities for practical work. His activities at Cambridge, however, were soon cut short, for in 1882 he was appointed Professor of Botany at Mason's College (afterwards the University of), Birmingham. Even this measure of assistance was consequently soon lost to Vines, upon whom after Hillhouse's departure the whole brunt of the teaching fell, the general elementary course coming under his charge. On the whole, however, this proved satisfactory rather than otherwise, for as Hillhouse had lectured at the Herbarium and Vines at Christ's College, the way to a more complete centralisation of the teaching was opened, and after a year or two all the study was conducted at the University Department.

The further developments at Cambridge fall naturally into the next chapter.

BOOK VIII

THE WAVE OF PROGRESS

BOOK VIII

CHAPTER LIV

BOTANY AT THE OLDER UNIVERSITIES, 1880-1900

The movement which had its origin at South Kensington during the seventies ceased to be confined to that centre after a few years. Its leaders were called away to other activities; Thiselton-Dyer found more and more to occupy him at Kew as, owing to Sir J. D. Hooker's advancing years, the departmental duties came to rest with gradually increasing concentration on the Assistant Director. The activities with which Vines had become associated at Cambridge confined him more and more to the University. The keener of the students had found starting places of those careers which led them into other scenes of work and called them into various parts of the world. So the centre of botanical development that had apparently been fixed at South Kensington underwent displacement and removal. The last course of lectures was given in 1880, and thenceforward matters botanical there became questions of routine under the Science and Art Department. But what was Kensington's loss became Cambridge's gain and the centre of gravity of the subject was transferred to the University where Vines continued for some years to take the lead.

Already he had caused a certain advance there; two departments of the study being in existence. The old school was under Babington, who continued the tradition of Henslow and Martyn by giving a course of lectures at the old Botanic Garden, then known as the New Museums, during the Easter Term. He had endeavoured to supplement the old teaching by appointing an Assistant Curator of the Herbarium and giving him a free hand to teach upon Sachs's lines. But Hillhouse, who was the Assistant Curator, was not brilliantly successful. He had no laboratory and could, therefore, do little more than lecture. Still, his work was useful as he took the elementary teaching, and thereby enabled Vines, in framing his own courses, to give more attention

to the advanced sections of the subject. Babington's own lectures were of no value whatever; they consisted of descriptions of isolated types, chosen altogether at the discretion of the Curator of the Botanical Gardens, who sent down the specimens according to the supplies available. There was consequently no grasp of taxonomic principles either shown by the Professor or acquired by the students. The lectures were dull and uninteresting and consequently badly attended. Hillhouse, however, had carried out botanical excursions for several years.

There was a course of lectures given at Sidney Sussex College by a College lecturer, but they attracted little or no attention outside.

The great advance which was due to Vines was then personal to himself. Returning to reside in Cambridge after his last experiences in Germany, he had brought with him the Kensington methods and the enthusiasm the new departure there had kindled in him, and a new department was springing up, as we have seen in the last chapter. But the encouragement he met with was even in 1880 only partial and there was much against him. He had no helper in the teaching; from the lecture room he had to go himself into the laboratory. He had to provide and preserve the materials for his practical work, he had very few microscopes and scarcely any other scientific apparatus, and the exigencies of space in the laboratory made it necessary to repeat each course of practical instruction twice or three times with fresh relays of pupils. Still he was undaunted, and grappling with all these difficulties and discouragements he laid the foundation of the earliest and perhaps the most efficient of the schools of botany that sprang up in the United Kingdom.

In 1881-82, the year the present writer was first associated with him as a student, Vines gave three courses of lectures at Christ's College. In the Michaelmas Term 1881 he dealt with the Physiology of Plants; in the Lent Term of 1882 with their Anatomy, and in the Easter Term with the Classification of the Cryptogams. Babington had for the first time set aside for his use a small room in the Herbarium block and here he gave the practical work which illustrated those lectures, working assiduously every afternoon.

The strain was great—so great that it began to tell upon his health, which even then was not very robust. Fortunately in the next year he was able to obtain some help. Walter Gardiner, who had been one of his early students at Cambridge, and who had at

his suggestion spent a year in Sachs's laboratory at Würzburg, returned to Cambridge, and came to his assistance, first in conducting the practical work, and later as a lecturer, taking one of the three courses spoken of.

The year 1882 was noteworthy at Cambridge for another reason. In consequence of his father's death Dr. (now Sir) Francis Darwin decided to leave Down and take up his residence at the University. He was an old alumnus of Trinity College, whence he graduated with high honours in 1870. The intervening years had been spent partly in association with his father at Down and partly in study and research in Germany. He came back to Cambridge in the summer of 1882, and was thenceforward associated very intimately with the new teaching. He took up the natural history side of botany, and with but little delay he started those classes for the practical study of vegetable physiology which have always been so prominent a feature of the Cambridge teaching.

In the Long Vacation of 1882 a new departure was made in the association with Vines's course of a course of lectures given by the Assistant Curator of the Herbarium, who was then Thomas P. Corry of Caius College, Hillhouse having been appointed Professor of Botany at the Mason's College, Birmingham. Babington consented to the proposal that Corry should lecture on the Natural System of Classification, though he was unwilling that the subject should be under Vines. His encouragement did not, however, go very far—the lectures were given at Caius College, and there was no practical work except at the Botanic Gardens and in the open country. The new departure had, however, all the elements of permanence, and the practice was never discontinued. After Hillhouse's departure the elementary as well as the advanced teaching devolved on Vines.

After a few years of strenuous effort the work of Vines secured appreciation in the University. No one who was engaged in its active business could fail to be impressed with the energy with which he was devoting himself to the extension of this particular department, to the self-sacrifice which it involved, or with the success which was attending his efforts. Botany was associated in the minds of all outsiders with the name of Vines, and not with that of Babington. Though the latter was ostensibly the Professor the duties that properly pertained to the Chair were being discharged by the younger man, who by the strange irony of fate was without any internal recognition. Things could not for very shame be allowed to remain thus. As it was impossible to recog-

nise Vines's work by election to the Chair, a new post, that of Reader, was created for him in 1883, and the University as such became associated with his work. The new departure did not stop at this point; in 1884, in connection with some alterations in the laboratories made for the convenience of the department of zoology, a small building was set apart for his use, and the large lecture-room put at his disposal.

Further changes in the status of his associates were made at about the same time. Darwin was constituted a University Lecturer and Gardiner appointed Demonstrator. So the University made itself responsible for the new line of study, all the new offices being salaried ones, and the expenses of the laboratory being defrayed by the botanical department.

A little rest being thus secured Vines took up a task which had first occupied his thoughts in 1882, and which he had long desired to complete, but for which he had not been able to spare the time. This was the preparation of the work on the *Physiology of Plants*, which appeared from his pen in 1886. In the conduct of his classes he had greatly felt the need of such a work, but nothing was forthcoming in English, and most of his students were not capable of using with much freedom the work of Sachs. The book appeared slowly and with many intervals, but even an intermittent appearance was much appreciated by his students, to whom with consistent kindness he gave copies of the successive sheets as he was able to get them through the press.

For many years the book was the only work on Vegetable Physiology by an English author, the only one, that is, that was written on the lines of English thought. As we shall see, a translation of Sachs's *Vorlesungen* appeared a little later, but it was voluminous, and the line of treatment of the subject was not altogether lucid nor easy to follow.

The appearance of this treatise demands perhaps a more formal recognition than has been bestowed upon it. It was the first contribution of an Englishman to the new botanical literature, and it has been the forerunner of many another work till the contributions of Englishmen in this field have become comparable to those of continental authors. It was long a reproach that all the works on modern botany that were accessible to students were translations mainly from the German. It is not a little to Vines's credit that he was the pioneer in the removal of that reflection upon English science.

The changes of 1884 led to an increase in the number of botanical

students at Cambridge, and the larger accommodation soon became as inadequate as the smaller had been. The names of Vines and Darwin drew young aspirants from all quarters, and the crowding in the laboratories became a serious difficulty. In 1887 the University again came to the rescue, and erected a long building by the side of the Herbarium which afforded facilities for histological work for about 100 students simultaneously.

The advance of the new school of research, not only in Cambridge where several of Vines's pupils were at work, but in London and a few other centres, drew the attention of the leading botanists to the desirability of associating a new journal of publication with their work. There were in existence three journals in which botanical work could find a place, the *Quarterly Journal of Microscopical Science*, which was chiefly occupied with animal histology, the new *Journal of Physiology*, started a few years before by Foster, and almost entirely devoted to animal problems, and the *Journal* of the Linnean Society, whose subjects were mainly taxonomic. None of these seemed suitable for the work of the new school, which was varied, and was evidently likely to become of considerable dimensions. After considerable discussion it was decided to found the *Annals of Botany*, which started on a very successful career in 1887. Vines was associated in the editorship with Bayley Balfour, then Professor at Oxford, and with Farlow, the distinguished chief of the botanical department at Harvard University in America. The initiation of the new scheme and the early stages of its inception were carried out by Vines.

Henslow had amassed a collection of dried specimens of miscellaneous character to illustrate his lectures, but the present practice of preserving preparations in spirit had not come into vogue during his tenure of the Chair.

About the same time a beginning was made with the development of a botanical museum at Cambridge, under the auspices of Gardiner. For a long time it was of very small dimensions, but it gradually grew under the fostering care of successive curators, till at the end of the century it was large enough to occupy one of the wings of the new laboratory about that time constructed, and to be under the charge of a special official. Henslow's collection served as the nucleus for the new museum.

The new movement had Vines's sympathy, but his time was too occupied for him to take an active share in its development.

Vines's growing reputation was recognised in 1885 by his election to the Fellowship of the Royal Society.

But a sad blow to the school was impending. In 1888 the Sherardian Chair at Oxford became vacant and, somewhat to the surprise of many of his friends and to most of the world outside Cambridge, Vines decided to fill it. There was much to be said for his choice. Babington was still holding on, though he had for a few years ceased even to lecture, so that there was no likelihood of the Chair descending to the actual head of the department; the work was increasingly onerous, the number of pupils larger year by year. Certain rumours, too, of internal friction were afloat. To the great regret of the University Vines removed to Oxford in 1888.

At this point we may pause for a moment to review the development which had been in the main the work of one teacher. Before 1875 the students were few, there were no lectures on anything but elementary taxonomy, and those such as we have described. There was no laboratory, and the herbarium was not at their disposal. There was no teacher except the aged Professor and perhaps a College Lecturer here and there with no general following. In 1888 there was a staff consisting of a Professor, a Reader, a University Lecturer, a University Demonstrator, and two or three unofficial Lecturers. There were adequate lecture-rooms, ample laboratory provision for elementary students, certain rooms devoted to research, and at least the beginnings of a botanical museum. Among the students who had passed under Vines between 1880 and his departure may be noted, in addition to those already mentioned, Phillips, afterwards Professor of Botany at Bangor; Percival, associated with the study of scientific agriculture at Wye and at Reading; F. W. Oliver, who succeeded his father in the Chair at University College, London; Potter, now Professor of Botany at Newcastle; Vaizey, whose promising career was cut off by a premature death; Seward, ultimately Professor of Botany at Cambridge; and P. Groom, later Associate Professor at the Imperial College of Science at Kensington.

When we consider the work actually accomplished by Vines at Cambridge and the widespread influence he exerted on other centres of study through these and other pupils, it is possible to realise what a power he was at the end of the century in the botanical world. Certainly up to his time no one had done so much to develop the science in Cambridge, if one might not say indirectly in the whole of England. At the outset of the new departure he and Thiselton-Dyer stood as the foremost figures in

the field, a position of which certainly the last century did not see them deprived.

Vines's subsequent career at Oxford will occupy our thoughts more appropriately later. The fate of Cambridge teaching was jeopardised by his departure and a certain reorganisation became inevitable.

There were many loyal supporters of the school available, and the necessary readjustments were soon made. Francis Darwin became Reader, Gardiner succeeded him as University Lecturer, and a new Demonstrator was found in the person of C. A. Barber, just then graduating at Christ's College. These took on the bulk of the work, but special courses were given by Potter and by Vaizey. The loss of Vines was consequently felt much more by his colleagues than by the students, who continued to be supplied with all they needed. In the next year the staff was strengthened by the appointment of a second University Lecturer, in the person of A. C. Seward, who in accepting the work laid the foundation of a botanical career which culminated some sixteen years later in his succession to the Professorship.

With the appointment of Darwin as Reader the work in practical physiology to which he was greatly attached assumed a more prominent position in the direction of both teaching and research. There were few facilities for the latter; the private rooms at the laboratory were small and inconvenient, ill lighted, and not furnished with appliances for physiological research. Just about this time certain house-property almost adjoining the laboratory came into the possession of the University, and prompt action on the part of the Reader and his friends secured it for the department. It was a tumble-down inconvenient property, but much better than nothing, and at a moderate expense it was altered so as to satisfy the more urgent requirements, and came into use in 1890.

The position was improved still further in the next year, when from failure of health Babington decided to apply for the appointment of a Deputy Professor. He had not lectured for several years, and of late had not been able to get down to the Herbarium. Still always hoping for improvement he held on to the Chair as long as he could entertain the idea of returning. Darwin was appointed Deputy Professor and henceforth the whole direction of the subject passed into his hands. It was satisfactory thus to get rid of the kind of dual control which had always been an annoyance to Vines and an obstacle to progress. The year 1891 saw other

changes. The Demonstrator, Mr. Barber, was sent out by the Government to the Leeward Isles to exercise a supervision over the cultivation of the plantations. His post at Cambridge was filled by Frost Blackman, who in this way embarked on the physiological career in which he attained such gratifying distinction.

Gradually Gardiner's interest in the school fell off. He became more and more immersed in the work of Clare College, in which he held the office of Bursar, so that matters were concentrated in the hands of Darwin, who conducted them with skill and resource, developing alike teaching and research. He introduced a plan of obtaining the services of botanists from other educational centres who were specialists in certain branches of advanced work, getting them to give the more advanced students the advantages of special courses in their particular fields.

The stream of pupils who ultimately became distinguished was continued during Darwin's superintendence. Among them may be mentioned Burkill, now holding an important position in Singapore; Willis, lately Superintendent of the Botanic Gardens in Ceylon; and Pearson, now Professor of Botany at Cape Town; Bottomley, Professor of Botany at King's College, London; Biffen, later Professor of Agricultural Botany at Cambridge; Yapp, Professor of Botany at Aberystwyth; Gwynne Vaughan, distinguished later for his researches into the anatomy of ferns and now Professor at Belfast; and V. H. Blackman, ultimately Professor of Vegetable Physiology at the Imperial College of Science.

The year 1895 saw the next important change at Cambridge. The death of Babington had been long expected; he had reached a very advanced age, had held the Professorship for thirty-four years, but had passed, as we have seen, into a feeble state of health, which had for a long time confined him to his house. He passed away in the summer of 1895, having only enjoyed the leisure of his semi-retirement for four years.

Babington bequeathed to the Herbarium a very important collection of plants, accumulated during his long life, partly by personal exploration, partly by acquirement from other botanists and explorers. The Herbarium had been the zealous care of his professorial life. It was originally begun by Professor Thos. Martyn who bequeathed his *Hortus Siccus* to the University. Unfortunately for want of adequate accommodation for the bequest, the plants were very poorly housed, for the most part in a cellar in the old Botanic Garden, and they suffered much from damp. When Henslow was made Professor he found them much

decayed, not only dampness but insects having caused great damage. He did his best to remedy the mischief, but a great many sheets had been irretrievably ruined.

During his tenure of the Chair Henslow added a great many specimens accumulated by himself, and got together several valuable collections of exotic plants. The most notable addition was made, however, by Bentham, who passed on to the University the great herbarium of Lemann. Up to 1852 the University cannot be said to have possessed an authentically named consulting herbarium at all. In that year Dr. C. M. Lemann died, leaving a collection of some 50,000 species, partly collected by himself, partly acquired by purchase. He was a friend of Bentham, and before his death asked him to accept the legacy of the herbarium. Bentham dissuaded him, and got him to leave it to the University of Cambridge. They agreed finally that Bentham should examine the plants, take over what he might want for his own collection, and should then send the rest to Cambridge with any duplicates which he could spare. The University accepted the very handsome gift, and made a grant for the expense of transfer, mounting, poisoning, etc. Bentham went through the collection, classified and named the plants, and enclosed them in genus covers, so sending the University what was, apart from Martyn's and Henslow's plants, a valuable consulting herbarium. The work occupied much of his time for ten years, not being completed till 1860.

Babington continued the policy of his predecessor, and during his professorship many additions were made. The most important was the herbarium of Lindley, which was purchased in 1866 soon after his death. The wonderful collection of Orchids was not included, but the collection comprised some 58,000 sheets, which included many type specimens.

Nor were the lower plants neglected; in 1876 and 1877 the herbaria of Dr. J. E. Gray and of Mrs. Gray were acquired, containing together 3000 sheets of well-preserved specimens of Algæ.

Ten years later Lady Banbury presented to the herbarium the collection of Sir Charles James Fox Banbury. This is estimated to comprise more than 6000 sheets of Phanerogams, Ferns, Mosses, and Lichens.

Babington's own legacy consisted of nearly 55,000 sheets; it consisted of four collections, one of which had been practically combined with the general herbarium during his life, the sheets having been sorted in with the others, but distinguished by the

label: "Herb. C. C. Babington." The other three were: (1) British plants; (2) his collection of Rubi; (3) Arctic plants.

This handsome contribution made the Cambridge collection of British plants the best in Great Britain. To Babington is the credit of this chiefly due; he was ardently attached to British botany in particular, and in getting together his collection he enlisted the assistance of many British systematists of the middle part of the nineteenth century.

A handsome contribution to the herbarium was made in 1897, when Mrs. Packe presented to the University some 4000 sheets, mainly of Pyrenean plants, that had been collected by her husband between the years 1858 and 1893.

On the death of Babington expectation turned naturally to Darwin for his successor, but he was feeling the strain of the work, and was not unwilling to secure a rest from the official duties that he might give his available time to the prosecution of research. For some years he had devoted a great deal of time to purely literary pursuits, and his inclinations in those directions led him to a distaste for the details of teaching and administration, and decided him to stand aside for some younger man.

The election fell in due course upon one who was destined to prove the greatest of the Cambridge Professors of Botany, to lead the department to still greater triumphs than it had yet achieved, and to build up for himself a reputation for research which was almost unique. This was Harry Marshall Ward, whose name has already found a place in these pages, and whose early career gave promise of the distinction which he afterwards achieved.

Ward was born in 1854, and received his early scientific training in connection with the great revival of the early seventies. He soon attracted the attention of Thiselton-Dyer, with whom he formed a friendship that ended only with his death. His early successes at South Kensington were followed by the winning of a scholarship at Christ's College, Cambridge, where he graduated with high honours in 1879. Following the example of Vines he proceeded to Würzburg, and studied under Sachs. His first paper, an investigation into the structure of the embryo-sac, dates from this period. But he soon developed an attachment for the study of Fungi and the elucidation of pathological problems, which lasted as long as his life. After this period of investigation he went out to Ceylon as Government Cryptogamist to investigate the disease affecting the leaves of the coffee plant, and he traced out the life history of the fungus to which it proved to be due.

While there he took up other problems associated with various members of the same group, and attached himself almost entirely to mycology. Returning to England, he was made in 1883 Assistant Lecturer and Demonstrator in Botany at Owens College (afterwards the University of), Manchester, where at the time Williamson was Professor. He played there a part similar to that of Vines at Cambridge. He only stayed, however, for about two years, for in 1885, after an unsuccessful candidature for the Glasgow Chair, he was made Professor of Botany in the Forestry branch of the Royal Indian Engineering College at Cooper's Hill, near Windsor, a post he continued to occupy for ten years.

It will be convenient to defer the consideration of Ward's scientific work in detail. It may be said, however, that even at this time of his life he had built up a great reputation as a thinker and an experimenter, particularly, though not exclusively, in connection with Fungi and Bacteria. Not, however, as a mere systematist or morphologist—his researches had led him into more obscure questions of physiology and disease. He had also made his mark as an author, contributing memoirs of much importance to the leading scientific journals.

The brilliant work he had done, and the acumen displayed in his writings, paved the way to his election to the Cambridge Chair on Babington's death. Practically he had no competitors; Darwin, who had been Babington's deputy for some years, stood aside, and took a leading part in securing Ward's election.

No appointment in recent years at Cambridge, with the exception of that of Sir M. Foster to the Chair of Physiology, has been at once so popular and so successful.

Ward's work at Cambridge was largely administrative, for the academic duties of the Chair occupied much time. The necessity of extending his laboratory accommodation was pressing. But in spite of all he was indefatigable in his researches, which were even then his most loved pursuit. His view was always that the duties of a Professor were in the first place to advance his science, and that teaching should occupy only a subordinate position. Holding these opinions, he frequently toiled well into the night after a hard day's professorial work. So the classes enlarged, and research was developed. He rallied round him a number of earnest students.

But Ward did not found a large school of research. His work was perhaps too personal, and he was himself too much engrossed in it to develop such a school. Nor had he much patience with

slowness of thought; he liked people to work at his pace, and with similar perseverance, and endeavoured with no great success to make his pupils as energetic as himself. He attracted some few research workers outside his classes, and he directed them alike in their choice of problems for experimental inquiry and in their treatment of them in the laboratory. In some cases he collaborated with them in the research. But his heart was much more in the treatment of his own problems than in directing others.

He must be regarded as the most capable and the most energetic of the occupants of the Chair. He reorganised everything, attracted large numbers of students, and developed in them a love for the science. In administration he was eminently successful. Before he had fairly settled down to the work of the Professorship he initiated steps for the development of the laboratory. After several years of strenuous advocacy he induced the Senate of the University to build and equip the present buildings, which were erected in 1903 at a cost of upwards of £20,000. They were at the time of their erection second to none in Great Britain, suggesting rather an Institute of Botany than a University Department.

Ward was elected to the Fellowship of the Royal Society in 1888; he was awarded a Royal Medal in 1893, and he served on the Council in 1895 and 1896.

His writings were numerous in all the leading botanical journals and in the publications of the Royal Society. He was the author of several treatises on various botanical subjects, of which the chief were: The Oak, Disease in Plants, and a work on Trees in five volumes, which was incomplete at his death, the last volume being edited from his notes by Professor Groom.

Besides his own contributions to literature Ward prepared for the Clarendon Press in 1887 a translation of Sachs's *Lectures on Physiology*, originally published in Germany in 1882.

During these two decades considerable changes were taking place in the Botanic Garden, under the auspices of a new Curator, Mr. R. Irwyn Lynch, who came to Cambridge from Kew in 1879. The gardens had been established on the Trumpington Road site for some thirty-five years, and had been growing slowly but consistently. There was, however, no provision for the Curator, while the glasshouses were showing symptoms of wear and tear. The present residence for the Curator was erected in the year following Mr. Lynch's arrival. He was energetic and enthusiastic, and imbued with the Kew spirit, bringing to the old routine some enlarged ideas and infusing new blood into the management.

At the outset he rearranged the plant houses and made their contents more generally accessible and useful. In the year after his arrival he instituted a collection of growing medicinal plants in the open garden, and extended the number of those under cultivation in the houses, originating thus a feature which has ever since been maintained. The collection at the outset contained the type plant of *Pilocarpus jaborandi*.

In 1883 the rock garden was enlarged. It remained small for many years, but underwent considerable development about the end of the century.

In the next year the first ornamental bamboo collection in any garden was established around a piece of ornamental water, and two years later a number of hardy cacti were first successfully cultivated out-of-doors. They have continued a feature of the garden ever since, and make a striking appearance in front of the greenhouses.

The old glasshouses were inconveniently arranged round an irregular square area, and communicated only with one another and the centre. They were even in 1880 getting sadly the worse for wear, so that their reconstruction became more and more pressing as time went on. In the years 1888-91 a new range was built, consisting of a long corridor into which a succession of separate houses opened. The introduction of the corridor system was a new departure in Botanic Gardens, being almost unknown elsewhere. Connected with the main block was a filmy-fern house and laboratory, and just behind were three large glasshouses for culture purposes. The Garden now boasts a fine range of glass. The cost of these structural alterations amounted to nearly £6000.

One of the Curator's earliest innovations was the construction of a bog and water garden near the ornamental pond. It was first laid out in 1881-82, and was then the first of its kind. Ten years later it was considerably extended. It is kept shut off from the general garden.

The Garden was greatly hampered during these years by the difficulty of obtaining funds, an obstacle which we have seen has been in the way of most other institutions of like character.

Some help was received from a fund raised during several successive winters by the charitable in Cambridge, which was devoted to a kind of relief work for the unemployed. Many such labourers were given work in the Garden for four days in the week at the expense of the fund. In this way many operations were carried out which otherwise must have been left in abeyance.

At Oxford during these two decades some progress was made, but with less conspicuous success than was the case at Cambridge. We have seen that Lawson was both Sherardian and Sibthorpian Professor in 1880, and that he resigned the Chairs in 1883. Pending a new election the affairs of the botanical department were administered with conspicuous success by Mr. Chapman of Magdalen, one of the Curators of the Garden. In the next year the vacancy in the Sherardian Professorship was filled by the appointment of Dr. Bayley Balfour, then the Regius Professor of Botany in the University of Glasgow.

Balfour did much to make affairs more prosperous. He inaugurated certain changes in the teaching, and developed it along the new lines. Among his pupils was John Bretland Farmer, who was later to occupy Scott's Chair at South Kensington. Balfour saw him appointed Demonstrator of Botany in 1887, the post being then for the first time constituted.

Balfour was deeply interested in the Garden, and projected a number of reforms which were greatly needed. During Lawson's occupancy of the Chair but little had been done, and deterioration was again setting in. The scheme for the erection of the new range of houses had been formed, but no sign of a commencement of the work was noticeable. Daubeny's arrangement of the beds, partly on the Linnean and partly on the Natural system, was archaic and unnecessary, the former scheme completely out of date and having then no practical utility. Balfour remodelled the arrangement altogether, and replaced it by a plan by which the systematic herbaceous beds were made to follow the lines laid down by Bentham and Hooker.

But Balfour's tenure of the Chair was short. In 1887, owing to the death of Professor Alexander Dickson, the Regius Professorship of Botany in the University of Edinburgh fell vacant, together with the post of Queen's Botanist in Scotland and Keeper of the Garden. This Chair, in which his father had been seated during many years, which had indeed been the scene of his most active labours, naturally appealed to him with an overwhelming force, and moreover, he seemed the obvious person to fill it; family tradition and influence pointed to him; he had already held one of the Scottish Chairs and had shown himself one of the most able administrators of the time. In due time he was appointed to fill the Edinburgh post, and the Sherardian Chair was again vacant.

We have already alluded to the circumstances at Cambridge

which decided Vines to be a candidate for the succession. Naturally with his reputation there was no question of any serious opposition to his election, and he was chosen at once as Balfour's successor. He was at the moment at the height of his fame; as teacher, author, editor, and exponent of research he had no rival, and he entered on a career at Oxford that promised almost as great things as he had already achieved at Cambridge.

In the same year W. H. Baxter, who had been custodian of the garden for more than thirty years, retired, and was succeeded by the present keeper, W. G. Baker, under whose able management Vines secured a continuous development of the garden till the end of the century.

It must be admitted that some of the bright hopes that were then entertained by most botanists for the development of Botany at Oxford were not fated to come to fruition. Whether the atmosphere of Oxford lacked the stimulating vigour of the air of Cambridge the annals of the University as far as the science was concerned were on the whole dull. Vines found himself almost alone; there was no stimulating influence like Foster's, no public body playing the part taken at Cambridge by Trinity. On the other hand, there was a certain sluggish conservatism, not absent indeed at Cambridge, but at Oxford more potent and more influential in the management of affairs. The modern spirit of scientific investigation had not caught hold of Oxford as it had of Cambridge and the battle of progress was hard to fight. As a consequence the body of students from whom Vines could draw recruits was small and the building up of the school was comparatively slow. To add to his difficulties he lost the co-operation of Farmer in 1892, when, on Scott's taking the direction of the Jodrell Laboratory, he was appointed to succeed him at South Kensington.

Not that Oxford was lacking in good material. Quantity rather than quality was absent. Fortunately Vines had among his pupils one whose ability was very highly spoken of, Arthur Henry Church, who was appointed Demonstrator in Farmer's place in 1894, and who held the post till after the century closed.

In spite of all these initial difficulties considerable progress was made. The teaching was good and Vines certainly did not spare himself in the service alike of the science and of the University. Among the more distinguished of his pupils may be mentioned Darbishire, afterwards Lecturer on Botany in the new University of Bristol, and Bentley, who occupies a similar post at Sheffield.

Throughout these years Vines never lost sight of the claims of research, and while practising it assiduously himself always impressed those under him with a sense of its importance. It was during this part of his career that he carried out those investigations into the proteoclastic enzymes in plants with which his name is associated. The subject occupied him for many years; he first studied the decompositions set up in the pitchers of Nepenthes, and was the first observer to give a correct account of the enzyme which secures them. The inquiry was then extended into the peculiarities of the other proteases and led to the discovery of vegetable ereptase and the great generalisation that the vegetable proteases consist only of mixtures of the latter with peptase, the mixture showing the behaviour of the so-called tryptase.

These researches did not exhaust Vines's activity in the field of vegetable physiology, for he carried out many minor inquiries.

Before the end of the century his literary activity found expression in the preparation of his *Student's Text Book of Botany*, a very complete compendium of the subject, published in 1895, and in a more elementary text-book which followed the former at an interval of a few years.

As at Cambridge he attracted to his laboratory others besides his own pupils. Among those who carried out researches under him at Oxford may be mentioned Percy Groom, afterwards Associate Professor at South Kensington, and A. J. Ewart, now Professor of Botany at Melbourne.

Under the care of Vines, with the assistance of Baker, the Garden flourished. The scheme inaugurated by Lawson and pressed by Balfour for the erection of new greenhouses, after long-continued effort was crowned with success, and at a cost of about £3000 the present magnificent range of glass was built in 1893. Most of the old houses were pulled down to make way for it, only two small detached houses being retained. The range contains now one of the most important collections of water-lilies in the country, which are most sumptuously housed, and indeed constitute one of the most attractive features of the Garden.

The herbarium at the Gardens had been gradually built up during the successive Professors. It probably was commenced by a small collection of plants got together by a Capuchin monk, Gregory of Reggio, in the province of Bologna, in 1606. To this were added Morison's and Bobart's herbaria at the end of the seventeenth century, consisting of between 7000 and 8000 specimens. The Du Bois herbarium and the collections of Consul

Sherard added nearly 30,000 plants about twenty to twenty-five years later. Shaw's Barbary plants and the small collection of British plants made by Dillenius were the next contributions, and the accumulations of John Sibthorp in Greece during his two tours brought up the list at the end of the eighteenth century to nearly 40,000 specimens. Had Sibthorp succeeded in adding to it the Herbarium of Linnæus the collection would have been the finest in the world. As it was, in the opinion of Sir J. E. Smith it was the best in England prior to the arrival of the material gathered together by Linnæus.

In the year 1852 this magnificent herbarium received a notable accession by the bequest of a wealthy amateur, a Mr. Henry Fielding, the possessor of one of the most extensive collections of dried plants in England. Himself an ardent collector, he added to his accumulations by purchase as opportunity offered. In 1836 he bought the herbarium of Dr. Steudel, and in 1837 that of Prescott, consisting mainly of plants from European and Asiatic Russia. From the collection of Mr. Lambert he obtained a large portion of the Peruvian collections of Ruiz and of Pavon, and he accumulated other less important herbaria from other regions. The whole of this vast collection, amounting to something like 80,000 specimens, he bequeathed by will to the University of Oxford, and dying as he did in 1851 the Herbarium became in the following year one of the finest in the world. For many years it was housed in the Gardens, £2000 being voted from money received from the University Press for its maintenance, and a special vote of £1350 being passed for the erection of a building for its reception.

The care of the collection fell at first to the Professor of Botany, and Dr. Daubeny was occupied for a long time in arranging for its adequate housing. He was aided in arranging the specimens by Mr. Garnsey and Mr. Boswell, whose own herbarium was ultimately added to the collection. But all this took much time, and was carried on with a good deal of intermittence. It was not till 1895 that a Special Curator of the Fielding Herbarium was appointed by the Sherardian Professor, with the approval of Convocation.

This creation, and the appointment of Mr. Claridge Druce to take charge of the Herbarium, were two of the notable incidents of Vines's tenure of the Chair.

With Lawson's resignation in 1883 the Sibthorpian Professorship was, as we have seen, separated from the Sherardian Chair. Under

the new Statutes Dr. (afterwards Sir J. Henry) Gilbert, the capable administrator of Rothamstead, was elected to fill it, and having been re-elected in 1887 he occupied it for the full term of six years. During this time he gave lectures on Agriculture, and particularly on the experimental results achieved at Rothamstead. He did not, however, revive Dr. Daubeny's research work at the University. After 1890 the Chair was vacant for four years, and was then filled by the appointment of Warington, also of Rothamstead, to whose researches so much of our knowledge of nitrification in the soil is due.

Further reorganisation of the Professorship took place early in the next century.

CHAPTER LV

BOTANY AT OTHER EDUCATIONAL CENTRES

The Chair of Botany at University College, London, was occupied by Professor D. Oliver till 1882, when he resigned his active work there. He was appointed Emeritus Professor, a title he held till 1888. The duties of the Chair were discharged by Dr. Scott, with the title of Assistant Professor. Scott's tenure of the post lasted only three years, but those years were marked by great development of teaching and the adoption of the modern methods in which he had been trained. In 1885 the death of Huxley caused a vacancy in the Professorship of Biology at South Kensington. Instead of appointing a successor, the Department of Science created two Assistant Professorships, giving the charge of botany to Scott and that of zoology to Howes, who had been Huxley's assistant. Scott's removal from University College was followed after a short interval by the appointment of Professor Oliver's son, F. W. Oliver, who, at first nominally assistant to his father, became Quain Professor in 1888.

In 1892 Scott vacated the Assistant Professorship of Biology at South Kensington, going to take direction of the Jodrell Laboratory at Kew. He was succeeded by John Bretland Farmer, who had been for five years Demonstrator of Botany at Oxford. He had been trained there by Bayley Balfour, having graduated from Magdalen College in 1887. Farmer threw himself with great energy into the work at South Kensington, and in 1895 his Chair was made independent, and he became in consequence Professor of Botany at the Royal College of Science. His work since on cytology and allied problems has given him a great reputation.

At King's College, London, similar developments took place. Bentley was professor till 1888, when he was succeeded by Groves, and he in 1893 by W. B. Bottomley. Bottomley was educated at King's College, Cambridge, and both before and after graduating lectured on biology at St. Mary's Hospital. For a few months before his election to the King's College Chair he acted as Demonstrator for Professor Oliver. During his tenure of his Professorship he has been mainly occupied with agricultural problems.

A large number of institutes for the promotion of scientific education, chiefly by means of evening classes, sprang up in different parts of London during these two decades; each was endowed by municipal or public bodies, and a competent staff provided. Botanical teaching formed in almost all cases a part of the curriculum. The pioneer in this work was the Birkbeck Institute, in Chancery Lane, but numerous others gradually came into existence. The first botanical Professor at the Birkbeck was Dr. Rendle, who early in the new century became Keeper of the Botanical Collections of the British Museum. Ultimately several of these so-called Polytechnics became constituent colleges of the University of London.

In 1895 Carruthers retired from the Keepership of the botanical department of the British Museum, and was succeeded by George R. Milne Murray, a young Scotsman, who had been trained under De Bary at Strassburg, and had been associated with his former chief since 1876. His chief work was on Marine Algæ, on which he published many books and papers.

Great educational activity was manifested in the Provinces as well as in London during these two decades, and several institutions of University rank were established. Of these the first to call for notice was the Victoria University, which was founded in 1883 by the temporary union of the Owens College, Manchester, the University College of Liverpool, and the Yorkshire College at Leeds. Owens College had for many years been the scene of the activity of Professor Williamson, whose work on fossil plants has already been noticed. The several colleges maintained their own professorial Chairs, so that Williamson was not affected very greatly by the fusion. He continued his work till 1892, when he resigned, being succeeded by the present professor, Dr. F. E. Weiss.

At Liverpool the botanical school was at the time attached to the Medical Faculty, and was under the direction of a certain Dr. Shearer, who confined his teaching to the Phanerogams. A new department was formed and put under the charge of Harvey Gibson, a relative of Harvey the Algologist, and at that time Demonstrator of Biology in University College. He was an old alumnus of Aberdeen, and had after his graduation studied under Dickson and subsequently taught in the Universities of Aberdeen and Edinburgh.

Dr. Shearer gave up his work in botany in 1887, and Harvey Gibson was made responsible for all the botanical teaching with

the title of Lecturer. His difficulties recalled the trouble all had experienced who undertook the work on the new lines. No laboratory, no appliances, and very little money! Like the other pioneers he grappled courageously with the position, and in 1888 got together the beginnings of a laboratory, furnished with a few microscopes and other appliances.

Through the munificence and public spirit of many of the wealthy residents of Liverpool, notably of Mr. Holbrook Gaskell, an orchid fancier of considerable repute, this state of affairs did not last long. Nearly £10,000 was soon raised, and the lectureship was properly endowed. Additions were made from time to time to the laboratory accommodation. But the students increased in still greater proportion, and in 1892 Mr. Holbrook Gaskell, who from the first had been deeply interested in the botanical teaching, erected a new laboratory on the roof of the old college building.

In 1894, once more through the munificence of Mr. Gaskell, who completed the endowment of the new Chair, a Professorship of Botany was created, and Harvey Gibson was made the first Professor. The work of the department continued to flourish, and the students increased both in numbers and efficiency. The Professor was assisted by competent demonstrators, the first being Dr. A. J. Ewart, afterwards Professor of Botany at Melbourne, C. E. Jones, who later became Assistant Lecturer to Professor Farmer at South Kensington, and Dr. F. J. Lewis, now Professor in the University of Alberta.

At the beginning of this present century a large, new Botanical Institute was erected and equipped by Mr. (now Sir) W. P. Hartley of Liverpool, which placed the College in as favourable a position for teaching and research as any other college in England. Subsequently a Lectureship in Vegetable Physiology was established through the munificence of Sir William Hartley, to which the present writer was elected.

Biology seemed to appeal with less force to the authorities of the third constituent College, Leeds. There was in the Yorkshire College a Chair which was concerned with the whole subject, and which was occupied by Professor L. C. Miall. At the time of the constitution of the Victoria University he entrusted the Botany to the care of Mr. Harold Wager, an old pupil of Scott's at Kensington. Later it passed into the charge of Mr. J. H. Wilson, and finally, when transformed into a Chair, into that of Dr. V. Blackman, now of the Imperial College, and after him Professor J. W. Priestley the present holder.

Mason's College, Birmingham, was the scene of considerable scientific activity in which the biological subjects shared. The subject of Biology was originally dealt with by a single professor, as at Leeds, but in 1882 a separate Professorship of Botany was created and filled by the appointment of William Hillhouse who had been for some time Babington's Assistant at Cambridge. He worked strenuously for the advance of the subject, and effected a considerable development, but Birmingham did not become important as a centre of research. Mason's College became the University of Birmingham at the end of the century.

A somewhat similar advance was seen in Wales. The three constituent Colleges of the present University of Wales were founded independently, and ultimately each had its own Professor of Botany, Phillips at Bangor, Trow at Cardiff, and Salter, afterwards Yapp, at Aberystwyth. Good educational work was carried out at all three centres, but there was comparatively little opportunity for research at either.

The University of Durham was extended by the foundation of Colleges of Science and Medicine at Newcastle. In the former a botanical department, which ultimately became a Professorship, was founded in 1889, and at its head was placed M. C. Potter, at the time Assistant Curator of the Cambridge Herbarium.

CHAPTER LVI

BOTANIC GARDENS IN LONDON

Kew under Sir W. T. Thiselton-Dyer

THE retirement of Sir Joseph Hooker from the Directorship of Kew Gardens in 1885, at the end of twenty years' strenuous labour, was followed by the appointment as his successor of his son-in-law, Professor Thiselton-Dyer, who had been Assistant Director for ten years. During those years he had played no inconspicuous part in the maintenance and development of the Garden, and by his long experience and his intimate knowledge of the working and of the traditions of the now National establishment he was clearly marked out as its chief.

At first sight it seemed a very difficult task to follow two such Directors as had preceded him. It says much for the sagacity with which the plans had been laid by Sir W. J. Hooker at the outset that the difficulty was not so formidable as might have been imagined. The work left to do was rather the further development of the original idea, and the enlargement and extension of the activities that had for so long been characteristic of the Kew establishment. We have seen that this policy was followed in the main by Sir J. D. Hooker.

The grounds were enlarged in the year 1895 by the inclusion of the Palace Meadow, about 4½ acres in extent, lying on the north-west side of the gardens, and forming part of the grounds of Kew Palace. It was valuable not perhaps so much on account of its extent as of its affording more easy access to the western side of the Gardens from Kew Green. This was an annexation of part of the grounds of Kew Palace, the whole of which, including the Palace itself, became part of the Gardens soon after the end of the century. The Arboretum was brought into fuller relation with the rest of the Gardens by the pulling down of a separating fence in 1895.

The grounds surrounding the Queen's College were given over to the public by Queen Victoria in 1897.

The development of the Plant Houses was continuous and progressive. In 1887 a new house for Alpine plants was erected, and was enlarged in 1891. A house for filmy ferns was erected adjoining the Tropical Fernery in 1892, during which year, too,

No. 4 Conservatory was reconstructed. Besides other smaller erections the completion of the Great Temperate House was undertaken. The plans for this had been drawn as long ago as 1860, and part of it erected. Two octagons of 50 feet diameter were finished in 1861, and a central block 212 feet by 137 feet connecting them was built in 1862, and a raised terrace was subsequently made to accommodate two wings to the north and south respectively. These wings were, however, not erected at the time, and their completion was one of the features of this period. The southern wing was intended to be devoted to succulent plants requiring a warm greenhouse temperature. It was begun in 1895 and completed two years later; while the erection of the northern wing occupied 1898 and 1899. The former was made the home of the Mexican plants, while the latter housed those from the Himalayas. The present house for Pitcher Plants was built in 1897, and the Orchid House in 1898. Various other developments of the buildings, some of them for purely cultural purposes, also were undertaken.

An interesting structural change in the houses was carried out after careful experiments. The white glass in the greenhouses, which had been used at the outset, was in 1845 held to be somewhat unsuitable for the Palm House, and it had been gradually replaced in several houses by a different kind, tinted green. Gradually the green glass, of a rather darker tint than the original, was extensively used, the effect being to cut off about nine-tenths of the blue and of the red rays of sunlight, leaving for transmission mainly the yellow and green rays with a fair proportion of orange This was gradually ascertained to be unhealthy for the plants, and in 1889 white glass was substituted for it in the tropical fern house, with remarkably good results. After further experiments the green glass was given up altogether in 1894.

The arrangements for the water supply to the Gardens were remodelled and much improved from 1887 onward. The bamboo garden was made in 1891-92, and a sunk rose garden was laid out near the Pagoda in 1895. The water-lily pond, lying to the south of the lake in the Pinetum, was constructed in 1897.

Many of these features added greatly to the beauty and charm of the Gardens. Indeed, one of the main features of Sir William Thiselton-Dyer's administration has been the beautifying of the grounds. Not by any single effort, but by the adoption of a continuous policy, so that the features of the landscape have become more and more decorative, the walks and lawns more and more

attractive to the eye, and the beauties of the lake and ponds enhanced by the treatment of their surroundings, as well as the plants cultivated in them. Not that landscape gardening has in any way become obtrusive, or that artistic features have driven scientific ones into the background, but there has been a judicious blending of the utilitarian with the ornamental, which has made Kew one of the most charming gardens of the world.

Certain changes in the staff at Kew took place. Baker as Keeper of the Herbarium was succeeded by Botting Hemsley in 1899. M. C. Cooke, who went to Kew in charge of the Economico-botanical collection transferred from the India Museum in 1880, retired in 1892, being followed by George Massee. During these years he took charge of the collections of Thallophytes in the Herbarium. Cooke was the author of many works on Fungi, notably *Mycographia* and *Australian Fungi*, and in addition to making these personal contributions to literature he edited *Grevillea*, a quarterly record of Cryptogamic botany for the twenty years 1873-92. He was awarded the Gold Medal of the Linnean Society in 1903. His herbarium numbered some 46,000 specimens and was presented by him to Kew.

A more important departure was made in 1892, when the Jodrell Laboratory, which had been the scene of so much important work, was put under the direction of Dr. Scott, for whom the office of Honorary Keeper was established. Scott had been educated at Christ Church, Oxford, and had during his earlier years no particular attachment to botany. At the conclusion of his University career, however, he took it up and studied under Sachs at Würzburg, where he graduated as Ph.D. On his return to England he devoted himself especially to the study of the Anatomy of plants, and conducted several valuable pieces of research. Turning to academic life again, he became Assistant Professor of Botany with Professor Oliver in University College, London, in 1882. When, on the death of Huxley, the Chair of Biology at South Kensington was divided Scott was appointed to take charge of the Botany with the title of Assistant Professor. Here he stayed till he took over the charge of the Jodrell Laboratory in 1892.

His administration of the Laboratory was remarkably successful. Owing to his reputation as a teacher as well as an investigator he drew to Kew a constant succession of the younger men, while the unexampled facilities offered to many of senior standing by the combined laboratory and garden attracted some of the leaders in botanical and physiological investigation in England.

At the outset he was joined by Professor Williamson, just then retiring from his Chair at Manchester, who remained working at Kew till his death three years later. He and the Keeper collaborated in several important papers, dealing especially with the structure and affinities of Lyginodendron and Heterangium and other plants of the Coal Measures. After Williamson's death his mantle fell upon the shoulders of his younger colleague, who soon became the leading English authority on Palæobotany.

But the transactions of the Jodrell Laboratory in any detail are more appropriately dealt with elsewhere, falling as they did into several fields of research.

During Thiselton-Dyer's administration the assistance given by Kew to the development of the British Colonies by the advice and help freely tendered in botanical matters was maintained with assiduous care. Perhaps the most prominent of its activities in this direction was the effort made in 1897 to revive the prosperity of the sugar industry in the West Indies. An Imperial Department of Agriculture for these islands was set on foot, and Dr. Morris was put at the head of it. Morris, after a very successful career at various botanical stations in the Colonies, had been appointed Assistant Director of Kew Gardens in 1886, and from his great experience was well qualified to deal with a question so important. On his return from the West Indies after bringing the work to a successful issue, having taught improved methods of cultivation and instituted various other industries, he received the honour of knighthood.

A similar enterprise was undertaken in 1891, when an Agricultural Department of the Leeward Isles was founded and filled by the appointment of Mr. C. A. Barber, at the time assisting Francis Darwin at Cambridge. Mr. Barber some years later became the successor of Lawson at Ootacamund in India, after a short interval of three years, from 1895 to 1898, when he held the post at the Royal Indian Engineering College at Cooper's Hill, vacated in the former year by Marshall Ward.

Kew was the scene of considerable activity in the literary world during these years. Reference has already been made to the great *Index Kewensis*, conducted under the supervision of Sir J. D. Hooker. This monumental undertaking was completed in 1895, when the last of the four great volumes saw the light. The *Index* gave the authentic name of more than 400,000 species of plants with their native countries, and became the recognised authority on nomenclature.

In 1887 a new periodical publication, bearing the honoured name of the *Kew Bulletin*, was commenced under the editorship of the new Director. It was the official organ of the gardens, and was chiefly devoted to the botanical and economic products of the Colonies.

The publication of the *Hand-lists* of plants cultivated at Kew on the lines of the old *Hortus Kewensis*, which began in 1894, was completed in five years.

The old periodical, the *Botanical Magazine*, now more than 100 years old, and associated with so many honoured names, was published in regular course, as was Hooker's *Icones Plantarum*.

Sir Wm. Thiselton-Dyer added to his onerous work as Director considerable literary labour as his predecessors had done. The work which specially is associated with his name as editor is the great *Flora of Tropical Africa*, which, begun by Professor Oliver in the late sixties, was suspended for some years after the appearance of the third volume. It was taken up by the Director in 1892, and occupied much of his time till long past the end of the century. He was also the editor of the *Flora Capensis*, the publication of which was revived in 1896.

The severance of Chelsea from the Apothecaries' Society

The decadence of Chelsea physic garden as an educational institution failed to be checked by the energetic work of Ward. He left no successor with the requisite ability even to continue the temporary revival of prosperity. So the burden of its maintenance was felt more and more irksome during the eighties, till at length the Apothecaries' Society determined to surrender it. This step, however desirable from their point of view, did not prove so easy as they wished. It involved not only the giving up of the property, but the relinquishment of the Trust. They had already in the past negotiated for relief with both the Royal Society and the Royal College of Physicians, but those negotiations had led to no result. In 1893 they appealed to the Charity Commissioners for a scheme of relinquishment alike of property and trust, and a Treasury Committee was appointed to inquire into the whole matter. At the moment a need was making itself felt by the students of the Botanical department of the Royal College of Science at South Kensington, established as an indirect result of Huxley's work some twenty years before. They had no provision at the College for the supply of specimens, and no access to any garden nearer than Kew or Regent's Park, both of which were

inconvenient for them, owing partly to the necessary restrictions and partly to distance. The idea of making the Chelsea Garden available for them for the purposes of study appealed to the Committee, who investigated forthwith the suitability of the garden for the purpose. The excuses of the Apothecaries for their proposal to give it up included complaints of the infertility of the soil, and the impossibility of cultivating the needed medicinal plants in such an atmosphere as London now presents. The result of the inquiries set on foot by the Committee satisfied its members that the garden was "still well fitted for botanical purposes, and that its advantages were likely to be highly appreciated by the students of the Royal College of Science and of the various Polytechnics." The question of funds for the maintenance of the garden was a serious one, for the conditions of the houses especially called for a considerable outlay if a fair degree of efficiency was to be secured. The Trustees of the London Parochial Charities agreed to contribute £800 per annum towards the upkeep of the garden, and the Treasury consented to supplement this by a yearly grant of £150. A scheme was consequently drawn up in 1899 by the Charity Commissioners, and the Trustees of the London Parochial Charities were created the Trustees of the Garden, the Society of Apothecaries surrendering their rights to them, together with their responsibilities. So the long and honourable tradition of the connection of the Apothecaries with the technical education of their craft was closed.

The new governing body appointed a committee of management to inaugurate and maintain the necessary arrangements, a very composite body, with at any rate a large representative element. It consisted of nine members appointed by the Trustees; one member nominated by each of the following: The Treasury, the Lord President of the Council, the Technical Education Board of the London County Council, the Royal Society, the Pharmaceutical Society of Great Britain, and the Senate of the University of London; one member appointed by the Society of Apothecaries and the Royal College of Physicians alternately, together with a representative of Sir Hans Sloane.

The immediate result of the change of government was a substantial alteration in the buildings at an expense of some £6000, the appointment of a new Curator, Mr. Hales, and a thorough renovation of the general arrangements for cultivation, so that at the beginning of the new century Chelsea was fitted to maintain its early reputation as the most efficient educational botanic

garden in the Metropolis. A convenient students' laboratory was one of its new features.

Chiswick

The decadence in the fortunes of the Royal Horticultural Society, which we have seen marked the late fifties, continued till 1887. The necessity of conducting flower-shows to secure funds brought the scientific status of the Society into a very subordinate position, and its true aims and objects were in danger of being altogether overlooked.

In 1887 the Commissioners of the 1851 exhibition, who owned the site of the garden on the South Kensington estate, took possession of everything except the library, and assigned the ground to other purposes. A reconstitution of the Society consequently took place; a hall was secured for its meetings and exhibitions and provision was made for the housing of the Lindley Library at Westminster. The publication of the *Transactions* was resumed, and efforts set on foot to restore the experimental garden at Chiswick, which had fallen into a sad state during the South Kensington period. The more scientific side of the Society's work was promoted by the re-institution of the Scientific Committee, which met periodically to consider questions bearing on practical horticulture. So the Society entered upon a new career of prosperity. Just after the end of the century the garden at Chiswick was replaced through the munificence of Sir Thos. Hanbury by a new one at Wisley, consisting of sixty acres of land. This property was placed in trust for the use of the Society, so long as it continued to be used by the latter for the objects aimed at by its founders.

The gardens of the Royal Botanic Society underwent but little alteration during the last forty years of the century. The Society was compelled, like the Horticultural Society, to wage a continual struggle against poverty, and it was able to do little for scientific botany. A few lectures by various scientific men usually during the early summer was almost all that was accomplished. The gardens were thrown open during part of every week-day to the students of the various medical and scientific institutions of the Metropolis. In 1873 a range of Economic Houses was erected, which was rebuilt soon after the century closed; these houses enabled a certain amount of useful work to be done, but on the whole the gardens played a very unimportant part among London's botanical institutions.

CHAPTER LVII

CONTEMPORARY BOTANY IN SCOTLAND AND IRELAND

The extension of modern methods of botanical study into the University of Glasgow may be associated with the appointment of Professor I. Bayley Balfour to succeed Alexander Dickson in 1879. Prior to that time, the teaching had been sound, painstaking, and thorough. The methods of the class-room, the garden, and especially the botanical excursion had been fully justified by their results. But the stirring changes which the seventies had seen in England had not reached Glasgow. At Edinburgh matters were more advanced, for Professor Hutton Balfour had added laboratory work to his curriculum.

Professor Bayley Balfour was the son of the Edinburgh professor, and had spent his life so far in botanical surroundings The son of so distinguished a teacher, he was from his youth a trained botanist. That he took no active part in the South Kensington revival was due in large measure to the fact that, like so many other noted men, he gave evidence of a desire to take part, while a young man, in botanical exploration. He went out in 1874 as one of the naturalists attached to the expedition sent to Rodriguez to observe the transit of Venus in that year, and he conducted an exhaustive examination of its botany. In 1878 his report was published. In it he showed himself competent to deal not only with the flora, but with the other natural features of the region. He described nearly 500 species, many of which he found peculiar to Rodriguez, and he reported fully in the general facies of the flora. His breadth of view was shown by the elaborate account he gave of certain morphological features of many of the plants, quite apart from their taxonomic characteristics, and the discussion of their physiological relationships with which he concluded his account of them.

In 1878 a committee of the British Association organised an expedition to explore the natural features of the island of Socotra, and Bayley Balfour was entrusted with the charge of the botanical investigations. The expedition left England in January 1879, and its members spent seven weeks on the island.

In addition to making a fairly comprehensive examination of

the flora, in the course of which Balfour collected between 500 and 600 species, he made some valuable observations on the general character of the flora from the point of view of geographical distribution.

He reported it to have a continental island flora, possessing features of considerable antiquity. It showed a great degree of individuality, its affinities being mainly African. He traced marked connections with Madagascar, Cape Colony, and the coast line of Somaliland and Abyssinia, while some Arabian representatives were found. In the other direction, only a few appeared related to the North Indian flora.

Balfour held that the character of the flora supports the theory of Sir J. D. Hooker, that there was formerly an ancient African flora of which now the Cape plants form the South, the Abyssinian the North, and the Madagascar flora the East extension. Hooker's suggestion had been that the South African flora had been once continued along the highlands of East Africa from Natal to Abyssinia.

The full account of the Socotran flora was published by the Royal Society of Edinburgh.

Just before Balfour's departure he found himself called to fill his first professorial Chair, which had been occupied by his father before him, and he entered upon active work at Glasgow on his return.

One of his early departures was the establishment of laboratory work on the lines laid down by Thiselton-Dyer at Kensington. He arranged to hold it on the lines of voluntary classes, recognised by the Senate and the Court of the University.

Another important feature of his short tenure of the Chair was the thorough reconstitution of the Botanic Garden, which was more or less remodelled and made efficient as a scientific establishment. Under his guidance the large range of teak houses was built at a cost of £20,000, and the elegant Winter Garden was constructed.

In 1883 the departure of Professor Lawson from Oxford caused a vacancy in the Sherardian Chair, and, much to the regret of Glasgow, Bayley Balfour was selected to fill it, and removed to Oxford in 1884. The vacancy was not easily filled. Many of the most influential botanists supported very heartily the candidature of Marshall Ward, who had recently acquired a great reputation from his investigations in fungology and its relation to disease. His researches into the pathology of the leaf diseases of Ceylon had

proved to be of the greatest value, both from an economic and a scientific standpoint, and appeared likely to receive recognition from the Government.

On the other hand, many local influences were enlisted in favour of Professor McNab, of Dublin, but he was not acceptable to the University authorities. Consequently there was a difficulty in selecting either, a difficulty which was only solved by the selection by the Government of a third candidate. After a certain delay the matter was settled by the nomination, in 1885, of the present Professor, Frederick Orpen Bower.

Bower was a member of an old Yorkshire family long resident at Ripon. He had been educated at Repton and subsequently at Trinity College, Cambridge. His botanical work had been under the direction of Vines in his earlier years there, and after graduating he had studied and worked in Germany under Sachs. On his return to England he found a temporary home in the Jodrell Laboratory, which was the scene of his earliest researches. He was soon appointed to a Professorship at the Royal School of Mines, from whence he moved to Glasgow on his appointment to the Professorship.

Bower brought to his work an enthusiasm for both teaching and research that was unsurpassed by any of his contemporaries. He developed his University work on the lines his predecessors had laid down while he maintained to the full all the older traditions as to lectures and excursions. But the new teaching was carried on under great difficulties; the University could furnish very little accommodation in the way of laboratories, and there was very little that could be called a herbarium. The aspirations for fuller provision in these directions met with little gratification for several years, in spite of continual agitation, but Bower was successful at the very close of the century in securing the erection of a well-furnished Institute on a site in the University Grounds, where accommodation worthy of the subject and of the Professor was available.

Bower continued the close relations with the Botanic Garden that had been maintained by his predecessors, but as the establishment was not formally attached to the University he was not able to exercise any direct control over its working.

In 1892 the Council of Queen Margaret College became incorporated at the University, and the buildings and grounds, with their endowments, were transferred to the University Court on condition that they should be devoted to the establishment and

maintenance of University classes for women only. The transfer took effect in 1893, when the College was dissolved. The incorporation led to the opening of the University classes in botany to women on the same terms as men. Prior to this the botanical teaching there had been under the organisation of the Professor.

Among the staff of the botanical department of the University may be mentioned the names of Dr. Willis, subsequently Director of the Botanic Gardens, Peradeniya, Ceylon, Dr. Lang, afterwards Professor of Cryptogamic Botany in the University of Manchester, and Mr. Gwynne Vaughan, later Professor of Botany at Belfast.

Professor Bower's researches are alluded to in a subsequent chapter. They received recognition in his election to the Fellowship of the Royal Society in 1891.

The new departure was longer in establishing itself at Edinburgh. On the resignation of Professor Hutton Balfour in 1879, Professor Alexander Dickson succeeded him. He had already achieved considerable distinction as a writer and an investigator of many problems in morphology and minute anatomy. His experience as a teacher had been wide; he had been connected with Aberdeen, and had held professorships in Dublin and Glasgow. Though possibly teaching did not appeal to him with the same force as it had done to his immediate predecessors, he came to his new sphere with a very great reputation, and there was no falling off in this department while it was in his hands. He was full of personal magnetism, and attracted the students to botanical work as much perhaps by his own charm as by the intrinsic importance of his subject. He spared no pains to elucidate for them the difficulties which they individually encountered, and was untiring in his efforts to develop the school. He maintained the old tradition of the importance of the botanical excursion, which became in his hands one of the most prominent educational features.

Dickson held the Chair till his death in 1887, when he was succeeded by the present Professor, Isaac Bayley Balfour, the son of his own predecessor.

Balfour brought with him to Edinburgh a great and varied experience, and perhaps a broader outlook than either his father or Professor Dickson had possessed. He had borne the work of much reorganisation at Glasgow, had modernised the teaching, and had practically been responsible for initiating the reforms which it fell to his successor to carry through—he had become intimately familiar with the spirit of University life in England,

and had begun to impress himself upon the course of affairs at Oxford—he had had experience of travel and botanical exploration. In both his previous professorial spheres there had been laid upon him the burden of developing or perhaps even of renovating a botanic garden which had fallen behind modern ideas and requirements. In both also he had been associated with the actual introduction of the laboratory methods of study, which were to be a feature of the University work of the immediate future. As for many years matters had advanced but little at Edinburgh it was clear that much administrative work lay before him and the claims of organisation would be pressing. It was equally certain that, in the new Professor, Edinburgh had the man she needed.

The work of reorganisation which occupied Bayley Balfour till long after the end of the century is in some danger of being overlooked. It was done with a quiet unobtrusive zeal, which looked almost like self-effacement. But it was done with pertinacity, with continual effort but with no outbursts of excitement. It involved the surrender of those botanical expeditions which were so attractive to him, and in which he had made his mark in connection with Rodriguez and Socotra. It prevented him from taking rank with the active morphologists and physiologists of the time. But it did not hinder his impressing his personality on the literature of the time, nor his making himself felt among the learned societies and scientific congresses of the century.

He was elected a Fellow of the Royal Society in 1884; he was twice a sectional President of the British Association—in 1894 over D at Oxford, and in 1901 over K at Glasgow—and he was made a member of many foreign botanical institutions.

The care, thought, and incessant labour which he bestowed upon the garden at Edinburgh have led to its practical reconstitution. Houses, staff, laboratories, museum, herbarium, library—not one has been neglected or allowed to fall into a suspicion of inefficiency. The Arboretum has been greatly developed, and has been thrown into the garden; an entire new suite of houses has been erected; a Rock Garden has been laid out; new laboratories have been built. The development of the museum has been a matter of great care, and it has been enriched with numbers of dissected specimens of the greatest value to students as well as to the general observer. It is no mere accumulation of possibly inchoate material —everything has been made the most of, and its illustrative value insisted on.

It is naturally impossible to say that all this rejuvenescence

was secured before the end of the century; there has been no break in the activities of either Professor or staff. Certainly, however, the last years of the century at Edinburgh were among the most remarkable that the botanic garden had seen.

In Dublin Professor Percival Wright was conducting the botanical work in connection with Trinity College and the Herbarium during the whole of this period. He gradually devolved much of the teaching to H. H. Dixon, who became his assistant in 1894, and who succeeded him as Professor ten years later.

Professor McNab held the Professorship of Botany at the Royal College of Science till 1889, when he died. He was succeeded by the present Professor, Dr. T. Johnson, one of the alumni of South Kensington.

McNab had been appointed in 1880 Scientific Superintendent and Referee of the Garden at Glasnevin, just after the death of Dr. Moore, who had been so long the Curator. Mr. (now Sir) Frederic Moore, who succeeded his father in that office, co-operated with the Professor in the development of the garden for several years, and considerable improvements were made. In 1883 severe autumnal gales seriously injured the Palm House; it was consequently removed, and a new one built during the next year at a cost of £5000. It was decided also to remove the old Octagon House and replace it by a new fernery, which was effected during 1886 and 1887, an alteration necessitating several changes in the walks and grounds. In 1887 the main walk leading from the entrance gate was altered and remade, and the rose garden remodelled. During the year 1888 many changes were carried out in the grounds, chiefly involving rearrangements of the principal walks. In 1889 considerable attention was paid to the very complete collection of species of *Pæonia*, which were rearranged, and the nomenclature carefully corrected, the whole being planted in the next year in a new border 250 feet long near the enclosed garden. Other work of a similar character was undertaken with great advantage. Just at this time Professor McNab died. As Mr. Moore had shown himself a competent successor to his father the post of scientific superintendent was not renewed, and Mr. Moore took sole charge of the Gardens.

Among the further improvements which he introduced during the remainder of the century were the reconstruction of the bog garden in 1890, the laying out of the new rock garden for ferns in 1892-94, the formation of a wild garden in 1895, and the erection of a new house for succulents in 1897. Besides these more notable

enterprises the development and improvement of the general garden made great progress.

New offices were erected in 1890, near the entrance gate. They consist of Curator's office, clerk's office, and library on the ground floor, and on the upper floor laboratory, herbarium, and other rooms for the use of the Professor of Botany at the Royal College of Science. Professor Johnson gave his first demonstrations in the new laboratory in the next year.

CHAPTER LVIII

RESEARCH 1880-1900

Morphology of Recent Plants

As a consequence of the new departure introduced by Thiselton-Dyer and Vines research, work underwent a very noteworthy expansion. Not that a violent or sudden change set in, for many taxonomists were, and continued to be, at work in investigating herbarium material and in carrying on botanical exploration in fresh regions of the earth. The younger school was more and more attracted by the fascinations of the study of structure and function, and anatomical investigations increased in number as the interest in them grew. Indeed, the laboratory showed a tendency to supersede the field and the herbarium, both from the side of education and of new discovery. Its devotees were attracted by the new methods of work; the novelty of the secrets which the microscope was found capable of revealing appealed strongly to them, and developed in them an attachment to the study and elaboration of method and the advancement of technique. The lead given in this direction by the promoters of research in animal histology was readily followed. Though at first the methods of staining devised were mainly applied to the cell-wall, it was not long before the peculiarities of living substance were as much sought out in plants as they were in animals, the identity of "sarcode" with "protoplasm" having come into general acceptance. The fixing of the living substance so as to prevent shrinking and preserve natural structure was soon added to the differential staining that was found possible, and so distortion was avoided, and with it many of the dangers of misinterpretation that were inevitable at the outset of the new methods of inquiry. As time went on the introduction and the continuous improvement of microtomes led to a wonderful perfection in the preparation of sections of tissues, so much so as to constitute indeed a certain danger of misconception, section-cutting being frequently allowed to supersede a more complete dissection. Still, the general advance of technique led to the more ready elucidation of the details of structure, and the progress of the study brought about

more and more familiarity with the minutiæ as well as the grosser features of anatomy.

The study of structure was reinforced by the examination of function. The lines indicated by Darwin's work attracted many followers, who placed the latter first and studied structure as elucidating it. Gradually, too, chemical considerations made themselves felt, and chemical reactions were applied to the solution of histological problems. A new branch of chemistry gradually came into prominence—the chemistry of the living organism, or *bio-chemistry*, which was destined, in the hands of many brilliant workers, to throw much light on many of the problems of physiology.

If we turn to consider at the outset of this period of activity the progress of anatomical study, we soon find it undergoing a development that at once brought it to a large extent into line with the work of the systematists. The details of structure soon impressed observers with the necessity of dealing with their bearings on the larger questions of morphology, from which, indeed, they were seen to be inseparable. The problems of morphology in the light of the evolutionary hypothesis showed themselves inextricably associated with questions of phylogeny, and a group of fascinating problems presented themselves, demanding inquiry into the descent of the existing forms of vegetation, the relations of the lower to the higher groups, the gaps in the evolutionary line, the stages by which great changes have been effected. The record of the rocks assumed a new significance, giving a new meaning to the sequence of forms, and bringing them into greater prominence in the investigation of phylogeny.

Research consequently became the moving thought of large numbers of the new school, and laboratory activity began to appear as its main instrument, the older line receding for a time rather into the background. Not that the ideas of the great taxonomists of the preceding periods were laid aside; the aim they had made their own did not disappear—relationships and system were still sought, perhaps were still the primary object of research, but they were approached by a different path, and the scheme of classification so presented became the more complete as the importance of the Cryptogams in it was realised.

In these two decades many names became familiar words to all students. The number in the early years was comparatively small, and the work that each man did stood out with much conspicuousness, so that in many cases he became a leader of

botanical thought in some particular direction. Later on this individuality was not so easily obtained, for numbers increased, and, unhappily, the rush for fame made many publish prematurely, and led to much work being superficial.

Of those who in the early eighties took up the study of morphology on the new lines the first place must be conceded to Frederick Orpen Bower, who we have seen became Regius Professor of Botany in Glasgow in 1885. Educated at Repton and at Trinity College, Cambridge, he came under the influence of Vines early in his University course, and immediately after graduating he gave himself to research, putting himself in touch with the leaders of thought on the Continent by working for some time in Sachs's laboratory at Würzburg. On his return he was soon made a Lecturer on Botany in the Royal School of Mines in London, and he became one of the workers in the Jodrell Laboratory at Kew. He was absorbed in these two spheres till his succession to the Glasgow Chair. The onerous duties which then fell to his share did not take him from his investigations; he showed the same keen spirit at Glasgow that he had done at Kew, and up to long after the end of the century he showed how it was possible to combine the working of an onerous University department and the teaching of hundreds of students with a steady devotion to the investigation of most difficult and recondite problems in a field which had hardly been looked at, still less explored, till he set his hand to it. Nor was he less successful as a teacher than an investigator, among his pupils being Lang, much later Professor of Cryptogamic Botany at Manchester, and Gwynne-Vaughan, ultimately the occupant of the Botanical Chair at Belfast, both of whom achieved their reputation under Bower's guidance.

From the outset Bower showed a thorough appreciation of the inductive method in research. He put before himself large and important problems whose investigation involved prolonged inquiry, and the accumulation of the minute details of structure that characterised the types of individual occurring in large groups of plants. All his work was done with a view not only to elucidate problems arising directly from the nature of his material, but to make each investigation the stepping-stone to still larger ones. So the solution of one question became but the starting-point of another, and his work culminated in some of the most important generalisations that were put forward after the end of the century. It is impossible to speak of all the memoirs which he contributed to literature, but the most important of his earlier writings claim

attention as giving a certain importance to the period on which we are now engaged.

His earliest work at the Jodrell Laboratory was an investigation into the germination of the seeds of *Welwitschia* and the histology of the seedling, and was carried out in 1880. Sir J. D. Hooker had then recently investigated the adult plant, as we have seen, and had written the masterly memoir to which we have alluded. Bower's work was worthy to follow Hooker's. In the next year he published a second paper dealing with the further development of the seedling, and in 1882 he investigated the germination and embryogeny of another member of the same group, *Gnetum Gnemon*. These were very remarkable papers for the time; they constituted a new departure in the investigation of the resemblances between the different members of the apparently heterogeneous group of the Gnetaceæ.

Passing over some memoirs of less importance, we find Bower in 1884 investigating and dealing in a masterly manner with the large question of the morphology of leaf and stem in the Vascular Cryptogams and Gymnosperms. The true value of the leaf as a member of the plant had been the subject of some controversy among morphologists abroad, and Sachs had claimed that the fundamental conception of the sub-aerial part of the plant should be not *stem* but *shoot*, both stem and leaf being only differentiated parts of the latter. Eichler, on the other hand, had advocated the view that the leaf is morphologically distinguishable from the stem, and that the ideas of stem and leaf should be kept fundamentally distinct.

Bower, as the result of his investigations and his analysis of the sub-aerial parts in the groups he was concerned with, associated himself with Sachs, and pronounced against any fundamental distinction between the two, claiming the same treatment for both. He demonstrated that the same behaviour characterises both parts of the shoot, and that, like the stem, the leaf is a branched axis. He showed, too, that though winging is so characteristic of the leaf, this is not sufficient to make the latter fundamentally different from the stem, and he tested his hypothesis by an acute analysis of the plants of the groups with which he was concerned.

The next group of plants to which he gave his attention was the great class of the ferns, plants which always exercised a kind of fascination for him. In subsequent years he concerned himself on more than one occasion with schemes for their classification, basing his views on their structure and reproductive mechanisms.

His first work was not, however, taxonomic, but was directed to certain peculiar abnormalities occasionally met with in their life history. It was in 1884-86 that he observed a phenomenon to which he applied the name *apospory*, it being a case of reproduction without the occurrence of the spore in the life cycle. It was not altogether an unknown phenomenon, for Pringsheim had observed it a few years earlier in the case of certain Mosses. Bower showed that in the life history of certain ferns there were cases in which substitutionary outgrowths from the fern showed at once or ultimately the characters of the prothallus, the two life phases or generations passing from the one to the other by a direct vegetative process, no spore being formed.

In the course of his work he met with other curious abbreviations of the life cycle, the sporophyte being sometimes developed by a vegetative process or bud, the gametophyte being entirely suppressed.

In 1885 he published a very complete account of the morphology and anatomy of *Phylloglossum Drummondi*, a little Australian Lycopod, the result of his investigation being to show that Phylloglossum is a permanently embryonic form. He based his conclusion on a comparison of the young plant as developed from its tuber with the early stages of the development of the sporophyte of *Lycopodium cernuum* as described by Treub. This gave an important starting-point for the investigation of the morphology of the group.

Some further researches on the ferns took the form of a study of the apical meristems of the stems and roots of various families, which occupied him immediately after his removal to Glasgow. His views on the classification of the Natural Orders of ferns were put forward a little later. He showed with much skill reasons for considering that the bulky eusporangiate forms are more primitive than the leptosporangiate members, and in the course of his discussion of the relationships introduced the conception of the possibility of reduction having played an important part in determining the relative morphological value of the sporophyll and the foliage leaf. He suggested, indeed, that the latter may be regarded as a reduced sporophyll.

Many papers of minor importance followed, including researches on sundry points of the morphology of the flower, on the pitcher of *Nepenthes*, on the anatomy of the sporangia of *Helminthostachys*.

But the most important piece of work which Bower did at Glasgow prior to the close of the century was his investigation of

the morphology and anatomy of the spore-producing members of the Pteridophyta, which formed the subject of a series of memoirs between 1893 and 1903. This remarkable work contained the record of investigations into the formation, development, and structure of the sporangia of all the divisions of that large group. It constituted a wonderful piece of anatomical research, and led to more accurate views of the structure of sporangia than any other research of the period. It may well claim to be mentioned side by side with the investigations of Hofmeister.

The anatomical work was, however, altogether subordinate in Bower's mind to a great generalisation as to the origin of the sporophyte in the Vascular Cryptogams which had long occupied his thoughts. He had already in earlier years appeared as a strong supporter of Celakowski's views as to the place of the sporophyte in the vegetative life cycle, and the mode of its origination. In 1890 he had put forward a theory of its development from the zygote or fertilised cell in consequence of the migration of plants from an aquatic to a terrestrial environment. "Certain forms spread to the land where access of water was only an occasional occurrence; in these the sexual process could only be effected at time of rains or floods or copious dews . . . thus less dependence could be placed upon sexuality for propagation, and an alternative method of increase of individuals had to be substituted. This was done by the production of the sporophyte from the zygote; once fertilised, a zygote might in these plants divide up into a number of portions (carpospores), each of which would then serve as a starting-point for a new individual. In proportion as these plants spread to higher and drier levels . . . the dependence upon carpospores for propagation would increase: consequently the number of spores produced by each sexually-formed sporophyte must be larger. . . . Any increase in the number of spores entails greater supply of external nourishment during their formation; . . . the sporophyte itself assumed the function of nutrition, a higher morphological differentiation of parts followed and . . . for the first time stamped the sporophyte with a character of independence and permanence."

From this theory of the origin of the sporophyte as originally a sporangium, Bower passed to the idea of its very early assuming a strobiloid form, and suggested that in Phylloglossum we may see the nearest living ally, while all the varied forms of the Pteridophyta may be traced back towards such a condition. The original type he pictured as an unbranched, upright strobilus, in which all the leaves were sporophylls, and the sporangia of moderate size.

Such a form he held might be traced back to a body of the nature of a sporogonial head, not very unlike the condition in certain Liverworts, development proceeding on the lines of (1) sterilisation of the potentially sporogenous tissue; (2) formation of septa; (3) relegation of the spore-producing cells to a superficial position; (4) eruption of outgrowths (sporangiophores) on which the sporangia are supplied.

Bower's views found more complete expression in his great work, the *Origin of a Land Flora*, published after the close of the century.

The earlier work on the peculiar features of the living substance of plants was not done by English botanists, but the first proof that it is a coherent entity falls to their credit. The idea of the universal continuity of the protoplasm through the cell walls of contiguous cells dates from the time of the discovery of the structure of sieve tubes. It was much upon the mind of Sachs in the early eighties, and in 1882 he suggested an investigation into the whole matter to Walter Gardiner, who fresh from Cambridge was desirous of taking up research at Würzburg.

The methods of investigation then in vogue, which had been applied by Frommann and by Tangl with little success, were confined to swelling up the walls with sulphuric acid, and subsequently staining the swollen tissue with iodine. Such treatment was moderately successful with the coarse elements of sieve tubes, but was utterly useless with the delicate cell-walls of the greater portion of the plant. Gardiner was very successful in devising modifications of this technique, and discovered methods which enabled him to study the most delicate tissues. He modified the swelling reagent so as to bring about its action much more gently than before, and thereby avoided the destruction of even the finest threads; he introduced the use of aniline stains in addition to iodine. Again, he used the iodine before swelling the wall, and applied picric acid as a fixing reagent in conjunction with his stains. He was by his improved methods successful in demonstrating the continuity of the protoplasm in the cells of the endosperm of various seeds, and in ascertaining many facts about the arrangement of the connecting threads. His first results were published in 1883, and were on the whole of a somewhat preliminary character. He returned from Würzburg soon after, and the research was interrupted by his University duties at Cambridge.

A few years later he took the subject up again, and pursuing it very systematically, he published some very important results in

1897. To kill and fix his tissue he now employed a mixture of osmic acid and uranium nitrate, and he stained it subsequently with saffranin. The new reagent enabled the stain to penetrate the tissue much more readily, and so to reach the more delicate of the threads. He was able to show that in the case of pitted cells, the pit-closing membrane is always traversed by threads of protoplasm, and that other threads traverse the general wall. In non-pitted cells the wall is perforated by the threads, though there are no pits. He claimed to trace the threads to the fibrils of the nuclear spindle, which become imprisoned in the newly-formed cell-wall.

In a further paper published in 1900 he showed that in certain cases a dot can be distinguished on the thread in the region of the middle lamella of the cell-wall, and he interpreted this dot as the persistent nodal dot of the achromatic fibrils. From the dot the thread appeared to develop through the substance of the wall in both directions. He held accordingly that the perforations are coeval with the formation of the wall. This view was supported by various observations made on the distribution of the threads in the walls of oblong cells.

The last contribution to the subject made in the century was a very complete account of the structure and distribution of the threads in *Pinus* made by Gardiner and Hill in 1900. Though the most elaborate memoir of the time, it only confirmed and extended the observations already described.

Continuity of the protoplasm in the tissues of seaweeds was demonstrated by Hick. He examined the Rhodophyceæ in 1883 and the Fucaceæ in 1885, with similar success. Oliver studied the sieve tubes of the Phæophyceæ in 1887.

The new science of Cytology was recognised for the first time in these years. At first appearing in animal histology, botanists soon realised its importance, and among its pioneers were found many of the leading German and French botanists of the time. Contributions were soon made by many of the English school, and investigations of great importance were set on foot. The work of Gardiner on the continuity of protoplasm has already been alluded to. Only a few years later he published the results of an inquiry into the processes accompanying secretion by the tentacles of *Drosera*, the contraction of the pulvini of *Mimosa* and of the protoplasts of *Mesocarpus*. But more intimately associated with the structure of the cell were the researches upon the nucleus and nuclear division which came from several laboratories. Bretland Farmer

investigated the mitotic changes in several of the Hepaticæ in 1894-96, and demonstrated the existence of the centrosphere, a recent discovery in the animal cell. The nuclear changes in the embryo sac of Phanerogams were studied by Miss Sargent in 1896. More extended observations were made by several workers on the Fungi, of whom the most eminent was Harold Wager, then Lecturer on Botany at the Yorkshire College, Leeds. He worked over a large range of organisms from the bacteria to the higher filamentous fungi, and applied great manipulative skill to the elucidation of his problems. Among the forms he studied were several of the Phæophyceæ, a species of *Agaricus*, and one of the Hymenomycetes in which he for the first time detected centrospheres, and showed that the behaviour of the nucleus in division and the structures appearing in that process in the cell correspond closely to some of the intricate divisions of the animal cell. He examined also that disputed question, the occurrence of a nucleus in the bacteria and in the cells of yeast.

The nuclear changes in the Saprolegniæ were investigated by Trow in 1895.

The fungi were studied by many workers from a different point of view. Life histories began to be unravelled, and polymorphy, both of individuals and of reproductive processes, attracted much attention. The work in this direction, of Wager, Trow, Massee, and others, calls for mention here.

Perhaps the greatest attention was paid to the Algæ, though it was in the main directed either to systematic relations or to life histories of particular forms. Doubtless this was inevitable, for little had been done since Harvey's time, and a good deal of his work was empirical. From the taxonomic side good work was done by Holmes and by Batters, both of whom were very ardent in its pursuit. The life history of particular forms, and the peculiarities of structure of particular groups, were investigated by Johnson, Murray, Phillips, Darbishire, West, Harvey Gibson, and others, and a good deal of information was accumulated. Mention must be made of the researches of Bretland Farmer and Lloyd Williams on the Phæophyceæ, partly carried out in conjunction and to some extent independently. To them we owe our knowledge of the details of fertilisation in *Fucus*, the mode of growth and reproduction of *Dictyota* with much histological and cytological detail as to the sexual organs and the development of the reproductive cells.

The curious group of the Myxomycetes, once held to be fungal,

and again relegated to the animal kingdom, was studied by Lister in 1888, and the nuclear changes in the plasmodia were shown to exhibit karyokinesis.

The study of the higher Cryptogams also was attended with good results. In addition to the researches of Bower, to which reference has been made, the work of Harvey Gibson on *Selaginella* was particularly valuable. It took the form of a study of the comparative anatomy of all the vegetative organs as they are represented throughout the genus. The researches were begun at Strassburg, under Solms Laubach, and were continued at the Jodrell Laboratory at Kew, and subsequently at University College, Liverpool. They constitute the most complete account extant of the anatomy of a large number of the species of Selaginella, and form a most valuable monograph of the whole genus. They were published between 1893 and 1897.

C. E. Jones investigated the genus *Lycopodium* on the same lines in 1898, working in Harvey Gibson's laboratory.

The ferns attracted considerable attention, partly from an anatomical standpoint and from the point of view of the story of the alternation of generations. The controversy between the "homologous" and the "antithetic" theories of the origin of the phenomena, conducted principally by Scott and by Bower, attracted considerable attention to the study of apospory and apogamy in the group. A remarkable observation was published by Lang in 1897 and 1898 of the occurrence of sporangia on certain regions of the prothallus of *Scolopendrium* and of *Lastræa* when cultivated under particular conditions. The occurrence, remarkable as it was, was not held by the observer to constitute proof of the homologous theory, although this was claimed for it by several workers on the subject.

The anatomical side of the investigation made on this group received contributions of value from Boodle and from Bretland Farmer. The latter worked out many points of the structure of *Angiopteris*, and in collaboration with Freeman studied the histology of *Helminthostachys*.

The Gymnosperms were the subject of considerable study. A masterly memoir on the reproduction of *Pinus* came from the pen of V. H. Blackman in 1898. Worsdell investigated with much care the anatomical features of many of the Cycads. His paper on their stems appeared in 1896, and was only one among several of great merit. Scott also made contributions to our knowledge of the group.

Gwynne-Vaughan, who in the first decade of the next century made many contributions of the first rank to the knowledge of Pteridophytic anatomy, made his first essays in the field of research in the Jodrell Laboratory during the last few years of this period. He was occupied there under Scott's direction with some points of structure in certain Phanerogams, especially with polystely and with other distributions of vascular tissue in particular groups. His work, always careful and sound, gave promise even at that time of the brilliance which it exhibited some few years later.

The structure of secreting glands in the higher flowering plants was investigated by Acton in 1888, by Miss Saunders in 1890, and by Miss Huie in 1898. The two first mentioned studied sugar secretion in the flowers of *Narcissus* and *Kniphofia*, while Miss Huie examined the tentacles of *Drosera*.

Other investigations included Corry's researches on the flower of *Asclepias*, published by the Linnean Society in 1882, and the work of Scott and Brebner on isolated phloem bundles in stems in 1889, and on sliding growth in 1893.

With so much activity displayed in morphological and anatomical research, it is perhaps not surprising that the output in pure taxonomic work showed a certain diminution during these last decades of the century. But it was by no means at a standstill.

The flora with the fauna of Central America was worked out by Hemsley, and published in 1879-88. It was originally issued in parts, and bound up into five large quarto volumes, under the title *Biologia Centrali Americana*. The main work was preceded by three parts of *Diagnoses* of new species, which were written by Hemsley.

Another work of some importance was published by the Linnean Society, who devoted two volumes of their *Journal* to it between 1886 and 1902. It was an enumeration of all the plants known from China proper, Formosa, Hainan, Korea, the Luchu Archipelago, and Hong Kong, and was the work of Forbes and Hemsley. It contains a description of 2000 genera and 5000 species and varieties.

The *Flora Capensis* was resumed in 1873 at the instance of Sir Henry Barkly, Governor of Cape Colony. It contained contributions from numerous botanists in South Africa and in various European countries, and was edited by Thiselton-Dyer.

The *Flora of Tropical Africa*, one of the great Colonial floras projected by Sir W. J. Hooker, after having been declined by Sir

John Kirk was started by Professor Daniel Oliver, and the first volume appeared in 1868. It was contemplated that it would be completed in four volumes, of which the second and third appeared in 1871 and 1877. Circumstances caused the suspension of the work after that date, but under some pressure from the Government it was resumed in 1892 under the editorship of Thiselton-Dyer, and finally completed in five more volumes. Both this and the *Flora Capensis* remained unfinished at the end of the century.

Braithwaite published some important works on the Mosses, which were in the main taxonomic, though he illustrated them by careful drawings of anatomical detail. The first of them was *The Sphagnaceæ of Europe and North America*, which appeared in 1880. It contained diagnostic descriptions illustrated by thirty plates of drawings of natural size. A larger work, which extended over the years 1880-1905, was published in twenty-three parts, ultimately forming three volumes. It was entitled *The British Moss Flora*. This was the most complete work in the group which had appeared since the writings of Dillenius. It gave a description of more than 3500 species, dealing fully with diagnoses based on morphological and histological detail, and was beautifully illustrated by life-sized drawings. The work contained a critical examination of the genera, and a revision and discussion of their synonyms.

Another work of some magnitude was Plowright's *Monograph of the British Uredineæ and Ustilagineæ*, which was published in 1889. It contained full descriptions of the morphology and life history of about 900 species, partly based on the author's own observations, and partly a compilation from the work of other authors of eminence on the Continent of Europe. Plowright's own researches in preparation of this book occupied him for seven years, during which he made more than a thousand successful cultures. Publication of particular parts of the work was made as time went on, in the *Transactions* of the Royal and the Linnean Societies.

CHAPTER LIX

RESEARCH—*continued*

Palæophytology, 1880-1900

THE year 1880 found Williamson in his prime, engaged on the masterly series of memoirs on the Carboniferous Flora to which we have alluded. Then, and for long afterwards, he was the leading authority in England, and his writings formed the basis on which subsequent investigations were built.

As the years advanced the duties of his Chair became more and more distasteful. Marshall Ward had left him for Cooper's Hill, and had been succeeded by M. M. Hartog, who was made Professor of Natural History at Cork in 1882. He was followed by Hick, to whose activities we owe progress in the knowledge of the fossils, and whose researches on the cytology of the seaweeds also call for recognition. But even with such assistance Williamson felt the strain of academic life to be too much for his advancing years, and in 1892 he determined to resign and devote himself entirely to his work on the carboniferous flora. Another circumstance had some weight with him. We have seen he had had no particular training in Botany, and his acquaintance with the anatomy of the plant had to be acquired and developed as new demands were made for it. He concluded to enlist the collaboration of a botanist who had the experience which he lacked, and could deal with the anatomical structure of the fossils, which was becoming more and more important as investigations became more minute, and as the discoveries of modern anatomy compelled more detailed comparison of minute structure. He therefore moved from Manchester to London and joined forces with D. H. Scott, who was then the Honorary Keeper of the Jodrell Laboratory at Kew. Scott had for many years devoted himself to the study of general vegetable anatomy, and was the most prominent figure in England in that field at the moment. He had made Williamson's acquaintance in 1889, and a strong friendship had sprung up between them. The Jodrell consequently became the centre of palæophytological work, and a series of most important memoirs was set on foot. Unhappily, the association proved to be only

too short; Williamson's health was gradually failing, and after a collaboration of little more than three years he passed away in 1895.

The first of these joint memoirs dealt with the group of the Calamites and some features of *Sphenophyllum*, and was published in 1893. The second, which appeared in 1894, contained a demonstration that the fossils that had been called *Astromyelon* were the adventitious roots of members of this group; a view that had been put forward by Renault in France several years before.

The last memoir surpassed them both in importance. It dealt with two remarkable plants, *Lyginodendron* and *Heterangium*, whose systematic position was very much disputed. Lyginodendron had been observed by Binney in 1866, and had been named by him *Dadoxylon*, but he had made no detailed examination of its structure. Williamson described it in 1873, and more fully in later years, and may be said to have practically discovered the family to which it is now referred. In 1887 he called attention to the fact that, together with some other forms, it showed characters intermediate between the Ferns and the Cycads. Other works on the Continent described forms of similar type during the eighties, and a body of opinion was formed which held that such a group once existed. The plant in question, after being called *Dictyoxylon* by Williamson, was ultimately merged by him in Gourlie's genus, Lyginodendron. Its petiole was identified with *Rachiopteris*, its leaves with *Sphenopteris*, and its root with *Kaloxylon*, so that its vegetative features were practically reconstructed. Its internal anatomy was the main subject of the memoir of 1895, to which we are now referring. The disposition of its tissues recalled Cycadean structure, which was confirmed by Scott's investigation in 1897 of the anatomical characters presented by the peduncles of the cones of *Stangeria* and other recent genera. Heterangium was shown to be closely related to it in internal structure—in fact, the two genera soon stood out as representing a definite family, now extinct and having left no close representatives. Williamson and Scott suggested that the family itself had been derivatives from an ancient and non-specialised Fern-stock, from which they showed a marked divergence in the Cycadean direction. Of the two genera they considered that Heterangium was the most ancient, and stood nearest the Filicinean ancestry, Lyginodendron having advanced much further on the Cycadean lines. Thus they gave a definite demonstration based on comparative anatomy of modern groups, that there

existed in palæozoic times a stock showing such close affinities to modern Ferns and Cycads that it may be regarded as the ancestor of some families of both. The group was subsequently named Cycadofilices by Potonié.

This memoir was the last in which Williamson had any share. With Scott's collaboration he was engaged in the latter part of 1894 upon *Lepidodendron*, a genus in which he had done such conspicuous work in earlier years. His death in January 1895 cut these researches short, and they were never published.

His mantle fell not unnaturally on Scott, whose reputation in this field grew by leaps and bounds. During the rest of the century he published three important memoirs from the Jodrell Laboratory.

The first of these gave some hint of Scott's own leanings in research towards phylogenetic problems. Though a most skilful anatomist, with him anatomical details were of most interest as indicating natural relationship. He was inclined, further, to recognise that such relationships became most evident from correspondence in the structure of reproductive organs; hence much of his most important work was done on fructifications, fruits, and seeds.

Certain fructifications had been described by Binney and by Williamson years before, and a few had been investigated by Continental writers. In particular some strobili had been examined by Zeiller in France, and had been referred to Sphenophyllum. Williamson and Scott had described the histology of some of these in 1893. Scott had become possessed of one of these cones or strobili, and his first independent paper gave an account of his investigation of its structure. It proved to be a cone of even a higher degree of organisation than the others, and was shown to be the fructification of an allied genus. Scott gave it the name of *Cheirostrobus*, and concluded it to be related to the Sphenophyllum, which Renault had described in 1870, and whose affinities had been the subject of much discussion. Scott held it that both Cheirostrobus and Sphenophyllum "sprang from an old stock which existed prior to the divergence of the Lycopods and Calamarians. This common stock survived for a certain time side by side with these two divergent branches—between them as it were. Sphenophyllum is a group which had advanced very far along this third line of descent, so that its common characters with the other lines have become comparatively obscure. Cheirostrobus has retained more of the common

character, though reaching a high degree of complexity on its own lines." [1]

The second of Scott's memoirs was devoted to the examination of two Lycopodiaceous strobili which had been tentatively referred by Williamson to Lepidostrobus, but which presented certain peculiar features of difference from that genus. He discussed their structure very fully, and gave reasons for constituting with them a special genus, *Spencerites*.

In his last paper of this period, published in 1899, he gave the results of his investigation of the structure and affinities of *Medullosa*, a fossil found at Stalybridge, whose connection with Heterangium had been noted by Williamson. Scott showed that the general character of its secondary tissues suggested a relationship with the Cycads, while the general ground plan of its structure pointed to an affinity with the Ferns. It showed a very close correspondence with Heterangium, so far as the structure of its stem was concerned, resembling this fossil also in the arrangement of the adventitious roots, and in the structure of its hypodermal parts. He came, therefore, to the conclusion that the plant was another member of the Cycadofilices of Potonié, perhaps more closely related to the Ferns than the Cycads, but at any rate derived by fairly direct descent from a simple Fern stock. He opposed Renault's view of its being derived from a Lycopodiaceous ancestor, and claimed that it strengthened the view that the Cycads, and probably others of the Gymnosperms, arose from the great phylum of the Ferns.

Further investigations at and immediately after the close of the century led to the view that many of the fronds originally held to have belonged to Ferns are properly referable to this group, and that the predominance of the Ferns in Palæozoic times has been over-estimated. Scott suggested in his Medullosa paper that not improbably some of the seeds found in these palæozoic rocks might prove to belong to this newly recognised group. Soon after the end of the century this prevision was justified by the discovery, made by himself and F. W. Oliver, that the seed described by Williamson in 1877, and named by him *Lagenostoma*, was borne by Lyginodendron. In consequence of this and subsequent researches, the name Pteridospermæ was, with certain reservations, applied to the group.

Two other workers of this period made important contributions to the science, but most of their work was in the main descriptive.

[1] *Phil. Trans.*, 189 B (1897), p. 26.

Kidston contributed memoirs dealing with *Zeilleria* (1884), *Ulodendron* and its relationships (1885), *Pothocites* (1883), *Lycopodites* (1884), Carboniferous Ferns and Lycopods (1887-89), *Equisetum* (1892), and other forms. Seward wrote several papers including memoirs on *Cycadeoidea gigantea*, *Sigillaria*, *Glossopteris*, and *Lyginodendron*. He began in 1898 the publication of a handbook on Fossil Plants, only the first volume of which appeared before the end of the century.

CHAPTER LX

RESEARCH — *continued*

Vegetable Physiology

During the period of these two decades assiduous attention was directed by many observers to the more striking phenomena of the physiology of the plant. Under the influence of the work of Sachs and of Schimper on the metabolic processes, the question of the deposition and utilisation of the reserve materials became perhaps the most prominent of these.

The researches of Ritthausen and of Weyl introduced into the study of the vegetable proteins the methods of the animal physiologists, and an examination of the *aleurone grains* of Hartig led to an analysis of their contents into members of the large groups, of which numerous representatives had been demonstrated in the animal body.

The observations of Vines published in 1878-80, considerably extended our knowledge. He examined very thoroughly the seeds of a large number of plants selected from a considerable number of the Natural Orders of the vegetable kingdom. His methods were partly microchemical, but he also prepared large quantities of many of the proteins, and separated them from one another much more completely than had been done previously, and showed for the first time how closely animal and vegetable proteins resemble each other. He for the first time put the latter bodies upon a satisfactory basis, bringing them into definite chemical categories, and abolishing once and for all the fantastic groupings into which many of them had been gathered.

He was followed a little later by Martin, who writing in 1887, though dealing with only a particular group, was able to confirm Vines in many important particulars.

The method of the deposition of these proteins in the seed, and the determination that the living substance is concerned in effecting it, was ascertained by Rendle in 1888. He showed that the process falls into line with the work of Schimper's leucoplasts, the protoplasm of the cell acting in the same manner as the latter.

This view was put forward in opposition to Pfeffer's hypothesis of a mere mechanical precipitation.

The formation of starch grains in seeds, tubes, etc., had been shown by Schimper in 1880 to be due to the activity of a leucoplast. The peculiar features which mark its behaviour were the subject of a long inquiry by Salter in 1896, in the course of which he followed with great care the development of the grains of a large number of plants. He found that certain stages were of constant occurrence, and their sequence consequently described the method of construction by the leucoplast. The stages were the following:—

1. The starch grain is originated inside the leucoplast.
2. It begins by the appearance of a nucleus or *kern*, the position of which determines the shape of the grain; if it be excentric it is followed by an aggregation of the substance of the plastid to one side.
3. A faintly staining zone is formed round the kern, its marginal part gradually deepening in staining power, and constituting the first lamina of the ultimately striated grain.
4. The succession of a number of laminæ superposed upon the first, and capable of demonstration by staining. The outer layer, to which he gave the name of the *rand*, generally fails to stain and shows no lamination when young, but later exhibits the appearance of several layers in its substance.

Salter found that in excentric grains the more watery laminæ generally fail to be recognisable the whole way round the kern, causing the grain to become increasingly excentric.

He determined that the material secreted round the kern by the plastid is throughout the process definitely starch substance, and can be differentiated from the plastid by staining. Each layer is like its predecessors, and none of them shows any transition in composition between protoplasm and starch.

The storage of fat or oil was only investigated in England by Cunningham, and that only in the fungi. In 1880 he noticed that as nutrition became interfered with, drops of fat could be seen to form in the hyphæ, and apparently at the expense of the protoplasm. The question seemed indeed to be not so much the storage of fat as a fatty degeneration of the living substance.

Much more work was done on the methods of utilisation of the reserve materials, their fate during the germination of seeds, tubers,

and other vegetative structures for propagation being examined by numerous investigators.

Very early in this period attention was drawn to the part played by enzymes, or as they were then called, "unorganised ferments," in these processes. Indeed, the study of this aspect of fermentation began to be systematic and thorough only about this time. The close association of ferment or enzymic action with the germinative processes gave a great impetus to investigation in both these fields.

Nor was the idea of enzyme action confined to the utilisation of the reserve materials. The view that enzymes play many obscure parts in the metabolic processes found expression in the writings of physiological botanists—it was specially emphasised by Thiselton-Dyer in his address to section D at the Bath meeting of the British Association in 1888. As research went forward this connection was found to be more and more widespread. It will be convenient accordingly for us to review here much of the work that was carried out in both connections. By the end of the century much information had been gained as to the changes enzymes bring about, if not as to the nature of these bodies themselves.

At the outset investigation was directed to the extent of enzymic action in the germination of seeds. The only enzyme that had been discovered in this connection was the diastase that had been observed by Payen and Persoz in germinating barley in 1833, and by Gorup-Besanez and others between 1874 and 1879. Though other reserve materials than starch were known to be utilised in the nutrition of the seedling, no active agent had been discovered, though Gorup-Besanez had claimed to have found a proteoclastic enzyme in the seeds of the vetch in 1874. His results were, however, disputed.

The present writer was able in 1886 to demonstrate the existence of such a ferment in the germinating seeds of the lupin, and he carried out an investigation of its action, not only on the proteins of the lupin seed, but on others of animal origin. He showed it to be a vegetable trypsin, capable of splitting up peptones, and unlike animal trypsins to act in a faintly acid medium. This was the first observation of a peptoclastic enzyme working in the germinative processes, and it pointed to the probability that the travelling form of nitrogenous nutritive material is not peptone, or even a protein, at all, but some form of amido- or amino-acid. In 1890 he observed the occurrence of the same enzyme in the germinating seed of the castor-oil plant.

A very complete and careful study of the germination of several species of the Gramineæ, especially of Hordeum, was carried out in the late eighties by Brown and Morris, and published in 1890. These gentlemen were associated with the great brewing industries of Burton-on-Trent, and had made very elaborate investigations into the chemical processes underlying those operations. Mr. (afterwards Dr.) Brown was keenly interested in all those questions, and for many years had devoted himself to scientific study of the problems they presented, working with different collaborators on particular points. His labours extended over some thirty years, during which he investigated not merely the chemical problems which first attracted him, but many most important physiological phenomena to which allusion will presently be made. To the solution of these and kindred problems he brought a well-trained mind, clearness of perception, a cool and well-reasoning judgment, and a scrupulous regard for accuracy in the minutest detail, all combined with almost unrivalled technical skill and fertile ingenuity in devising experimental methods of attack. There is little wonder that his researches stand out as the most remarkable that the later years of the century saw in the field of vegetable metabolism. His work was recognised by his election to the Fellowship of the Royal Society in 1889, and by its award of a Royal Medal in 1903.

The study of the germination of the barley grain by Brown and Morris was the first complete investigation of such a process that was published. In the memoir the authors described minutely the histological structure of the grain and the appearances of the different tissues which appear as germination proceeds, tracing the series of changes, both structural and chemical, of which its various parts are the seat. They showed the embryo to be parasitic on the endosperm, and to depend on it only for nutritive materials, for the supply of which the endosperm serves only as a storehouse—being itself practically a dead material. They proved this important conclusion by dissecting out embryos and cultivating them on artificial nutritive media, composed of various starches and sugars. They studied the enzymes which are active in the utilisation of the reserve stores of carbohydrate, and showed that the germinating grain contains two varieties of diastase, one of which is secreted by the scutellar epithelium of the embryo when germination is set up. They examined the process of secretion in these epithelial cells, and showed how it agrees with the formation of enzymatic liquids in animal glands. They

detected a further enzyme whose existence had never been foreseen, a cytase, which dissolves and prepares for utilisation the materials of which the cell walls are composed. The investigations which they carried out on these two enzymes were very thorough; they determined their mode of action and the conditions under which it was effective, their localisation, and the processes of their secretion, and indeed gave us for the first time a vivid picture of the germinative changes so far as the carbohydrates are concerned, in place of the very, very nebulous sketch that had so far served.

Finally they made a comprehensive study of the various transformations of which the carbohydrates are the basis during the development of the seedling.

The existence of a fat-splitting enzyme or lipase, which had been predicated on slight evidence by Schützenberger, was detected by the present writer in the germinating seeds of the castor-oil plant (*Ricinus communis*) in 1890. A further examination of its working, and the phenomena accompanying and following it, was made by him in 1901. The study of this seed showed that unlike the endosperm of the barley grain, that of Ricinus is a living and actively metabolic tissue, not only furnishing organic substances to the embryo, but setting up chemical and physiological changes in the contents of its own cells whereby the reserve stores are made more easily utilisable.

The utilisation of inulin by the plants that contain it in their vegetative parts, particularly where it is a reserve material, was shown by the present writer in 1887 to be due to an enzyme, inulase. The occurrence of inulin as a reserve material in the bulbs and corms of certain Monocotyledons was ascertained by Parkin in 1899.

The germination of the pollen grain was the subject of an extended investigation by the present writer in 1891-94. He showed that it is largely under the control of enzymes, as is the subsequent growth of the pollen tube. The most commonly occurring enzymes are diastase and invertase, both of which have a wide distribution.

Other researches on the enzymes were directed to their action in other metabolic processes in autotrophic plants, their rôle in the leaves and other vegetative parts; to the nutritive processes in heterotrophic plants, especially those commonly called "Insectivorous," to the mechanism of the ravages of fungi and other parasites, and to the putrefactive action of bacteria.

Perhaps the most important memoir on the first of these topics was a remarkable paper by Brown and Morris on the Chemistry

and Physiology of Foliage Leaves, published by them in 1893. It was not the first in point of time, for Vines wrote a memoir on the same subject two years before, in which he showed that the leaves of grasses contain diastase, and the formation of the travelling stream of sugar in these plants is mainly the result of its activity. The work of Brown and Morris was, however, much more comprehensive, as it dealt also with certain of the problems of photosynthesis. The authors calculated, from the data which they determined by experiment, the actual quantities of carbohydrate material which were formed under different conditions of illumination by a unit area of leaf surface. They ascertained that sugar is the culminating product of photosynthetic activity, and not starch as Sachs had taught, starch being deposited in the leaf when the formation of sugar exceeds the immediate demands of the cell. They detected diastase in the leaves, as Vines had done, and they examined both qualitatively and quantitatively the products of its activity *in situ*.

While Vines had confined his experiments to the grasses, Brown and Morris examined a great variety of plants, and having compared various leaves as to their diastatic powers, they showed that while it is almost or quite universally present, its amount varies much in different leaves and in the same leaf at different times of the day and night. The variation showed a rough periodic rhythm, the meaning of which they discussed.

In the same research they examined the sugar contents of the leaves, determined the descriptions of sugar which are present and their relative amounts from time to time, with a view to determining the order and conditions of their formation. They came to the conclusion that in the plants which were the subject of their experiments cane sugar is the first produced.

Brown and Morris discovered that in addition to diastase, invertase is present in the leaves of many plants.

The digestive processes in the insectivorous plants had been examined by Darwin twenty years before as we have seen. Certain observations on the histology of the secreting cells of Drosera were made by Miss Huie in 1896 and 1899, which illustrated the mode of formation of the digestive juices. In 1896 Vines commenced an examination of the pitcher of Nepenthes and the fluid it contains, which not only showed the enzyme *nepenthin* to be peptoclastic, but served as a starting-point for an extended investigation of the proteases, which occupied him during the first decade of the next century.

In the early years of this period the nomenclature of ferment action was unsatisfactory. Enzymes and micro-organisms were classed together as "ferments," the latter being called "organised" to distinguish them from the former. The unorganised ferments, or enzymes, were beginning to be recognised as secretions from groups of cells, called glands, whence they were poured out to mix with the substances on which they worked. The organised ferment, on the other hand, was seen to be a cell itself, usually of bacterial, or perhaps of fungoid, nature. The present writer in 1893 pointed out that this distinction was unscientific, for a single cell may pour out a secretion just as can a mass of cells, while the protoplasm of a cell is capable of acting like a microbe though it be one of a large complex of cells. He showed, too, that enzymes can act intracellularly as well as when excreted from the cell or cells secreting them. The distinction between organised and unorganised ferments need not therefore be maintained. Indeed, nearly all the hydrolytic changes brought about by microbes have been shown to be due to enzymatic secretions which they form or enzymatic properties they possess. An enzyme can be formed in a unicellular as well as in a multicellular organism, and its extraction from either is but a question of method.

Certain questions as to the constitution of enzymes and the conditions of their activity were examined during this period. The deleterious effects of high temperatures, of the action of acids and alkalis, and of neutral salts had occupied the attention of the animal physiologists. A prolonged inquiry into the action of light upon various forms of diastase was conducted by the present writer in 1895-97. The action was shown to be two-fold, the rays of the red end of the spectrum being capable of converting the zymogen of the secretion into the enzyme, while those of the violet and ultra-violet regions are destructive. On exposure to the whole range of the spectrum the latter effects predominate.

An investigation was made by Croft Hill in 1897 and 1898 into the mode of action of glucase, an enzyme that had been found by Geduld to be capable of converting maltose into glucose, and he determined it to obey the law of mass action, the course of the digestion depending on the quality of the two sugars present. Working in dilute solutions of maltose, glucose was formed; but when the glucase was mixed with a concentrated solution of glucose, the reverse action took place, and some of the glucose was made to form maltose. He investigated the conditions of the

changes in mixtures of the two sugars in various relative concentrations.

Experiments were made by several physiologists on the very large and important question of photosynthesis, and some of the problems which are incident to it. The opinion of the great Frenchman, Boussingault, on the mechanism of the absorption of carbon dioxide had been accepted, and the gas was held on the authority of his experiments to be diffused into the interior of a leaf through its cuticular surface. Much opposition had, however, been encountered on the Continent, and opinion was slowly veering round to the view that the stomata furnish the pathway of entry. In 1895 Frost Blackman published some researches which he had carried out at Cambridge, which went far to establish the latter view. Blackman's method consisted of enclosing a leaf in two specially prepared glass chambers, so arranged that each face communicated with a single chamber, and the two were perfectly separated from each other by the lamina, which formed a diaphragm between them. A tube led to each chamber from a reservoir containing air to which a definite quantity of carbon dioxide had been added, so that the entering stream usually contained 1 per cent. An exit tube led from the chamber to a titration apparatus specially devised for the measurement of very small quantities of the gas. Each leaf was carefully examined with a lens to ensure that no perforations in its surface existed. A stream of air of this known composition was drawn through the apparatus for a definite time by an aspirator under proper precautions, to ensure a regular and measurable flow. The light was admitted to the leaves by exposing the apparatus either to direct sunlight or to the reflected light from a heliostat, and was made to fall upon the leaf at right angles to its surface. The results showed that the absorption of carbon dioxide follows extremely closely the distribution of the stomata.

The end of the century saw another remarkable memoir from the pen of Dr. Horace T. Brown, this time written in collaboration with Mr. Escombe. This dealt with the same problem, though it went further in its scope than Blackman's work. Brown and Escombe carried out their inquiry at the Jodrell Laboratory at Kew, and the resulting memoir was one of the most remarkable to which that institution gave origin during the period under notice.

Their first question was to determine whether on the hypothesis of stomatal absorption of carbon dioxide the pathway afforded by the opening is sufficient to admit as much of the gas as will furnish

the amount of carbon built up into the plant. Like so much of Brown's work the paper is remarkable as containing quantitative determinations and statistics bearing on the point. The observers succeeded in ascertaining that a leaf in active operation was absorbing carbon dioxide more than half as fast as the same surface would have done had it been wetted with a constantly renewed film of strong caustic potash. This was much more than would enable a leaf (in the observed case, that of a sunflower) to manufacture 1·8 gram of carbohydrate per square metre of surface per hour, the quantity which they determined by analysis of the leaf to have been formed.

They next made an elaborate inquiry into the mechanics of the absorption of carbon dioxide through diaphragms perforated by small apertures, and they ascertained that if the latter are sufficiently minute diffusion takes place through them as rapidly as if there were no separating partition at all. This result was reached in their experiments when the individual openings were sufficiently far apart to be unable to interfere with the passage of the gas through their nearest neighbours.

We consequently owe to Brown and Escombe a demonstration that the stomatal entry of the gas allows an ample supply for all the manufacture of carbohydrates due to photosynthesis.

The memoir went, however, far beyond this result; it showed that the intake is proportional to the tension of carbon dioxide in the air, and it extended the view of the transport of gases through small apertures to the translocation of nutritive materials in the plant through similar but finer openings in the cell walls shown to exist by Gardiner in his researches on protoplasmic continuity.

In this same memoir Brown and Escombe published a series of elaborate measurements of the efficiency of the foliage leaf as an absorber of solar energy. They determined that in the strong sunlight of an August day such a leaf absorbed 28 per cent. of the energy falling upon it; in diffused light it appropriated 95 per cent. They ascertained that of the absorbed energy 27·5 out of 28 per cent. was devoted to the evaporation of the water of transpiration, and ·5 per cent. applied to photosynthesis. In the case of the diffused light 2·7 of the 95 per cent. was devoted to the latter process.

In most of their experiments the leaves were not removed from the plants, but were enclosed in a case through which the air was passed over them, the carbon dioxide of the entering and the issuing streams being separately ascertained by analysis of samples.

In a subsequent paper they showed that it is not possible permanently to increase photosynthetic activity by supplying leaves with increased quantities of carbon dioxide. Though at first such a formation is shown the tissue soon fails to cope with the increased supply, and the plant becomes disorganised, structural changes rapidly supervening.

Though the living substance of the plant had come to be regarded as identical with that of the animal, the essential physiological correspondence had not been demonstrated in 1880. A series of papers of great importance was contributed to science by Professor (after Sir John) Burdon Sanderson in 1882 and 1888, which showed that the electric changes which follow stimulation and accompany the closing of the leaf are strictly comparable with those that are associated with muscular contraction. We have already alluded to these researches as having been commenced in the Jodrell Laboratory at Kew soon after its equipment. They were continued at University College, London, where Burdon Sanderson held the Chair of Physiology. The conclusion reached in the first paper, published in 1882, was that the first change after stimulation "was of the same nature with the excitatory variation, or action current of animal physiology, and must be regarded as the expression of a molecular change similar to that which occurs in nerve, muscle, or the electrical organ under analogous conditions." In a later memoir, published in 1888, these conclusions were confirmed and amplified, and the time relations carefully elucidated. These researches stood practically by themselves till after the end of the century.

The study of such phenomena conduced to a conception of a nervous mechanism of a simple nature in the vegetable organism, and many isolated inquiries into various features of such a phenomenon were carried out on the Continent. Such investigations did not appeal to many workers in England, but they did not pass altogether unnoticed. Francis Darwin, in the intervals of his administrative work at Cambridge, devoted a great deal of attention to the behaviour of stomata, and was led by his observations and experiments to some important conclusions of this nature. He published an elaborate memoir on the whole subject in 1898, which contains the following paragraph: "With regard to the general mechanism of the stoma, it is suggested that the pressure of the guard-cells and that of the surrounding epidermis should be looked at as correlated, not as opposed and independent factors. It is argued that the closure of the stomata in darkness is not

due to the starvation of the chloroplasts in the guard-cells, but is an adaptive action of the same type as the other phenomena of irritability in plants. A somewhat similar view is tentatively suggested for the closure which occurs during withering."

A further contribution to the physiology of the time which was received with some favour was the hypothesis put forward by Dixon and Joly in 1894, that the ascending stream of water in the vessels of the axis of a woody plant is lifted bodily up by virtue of its power of resisting tensile stress. A similar view was advanced almost at the same time by Askenasy in Germany.

Dixon and Joly, working in the laboratories of Trinity College, Dublin, showed that the cohesive property of water can be exhibited even though the columns are not free from air. They determined that under the conditions in which they exist in the wood they will cohere under a tension of about seven atmospheres, which is sufficient to raise the liquid as high as the leaves at the summit of a tall tree. The forces necessary to exert this traction, naturally sought for in the leaves, were described differently by the Irish and the German observers. Dixon and Joly suggested surface tension forces, developed in the substance of the walls of the evaporating cells. A second force they held to be the osmotic suction of the mesophyll cells, which draw water from the tops of the columns as the turgescence of the leaf tends to fall, and they thought it probable that this is the more powerful of the two.

This theory of the ascent of the sap gave rise to much controversy, but survived the criticism it encountered during the remaining years of the century.

Researches into the great question of the nitrogen supply to the plant were conducted during many years by Warington. As they were conducted at the experiment station at Rothamstead it will be more convenient to discuss them in connection with the progress of agriculture.

CHAPTER LXI

RESEARCH—*continued*

Vegetable Pathology

THE section of physiological work which lies on the border-line between health and disease, which is, indeed, more nearly allied to pathology, showed a series of notable researches which were associated almost exclusively with the activities of a single observer, but one whose work was perhaps in some ways the most remarkable of the researches of the century. We have already traced the career of Marshall Ward as a great figure in the fields of education and administration; it remains to speak of the investigations which stamped him as one of the most original thinkers and most earnest workers of his time.

His work was mainly concerned with a particular line of physiological investigation, the study of the relations of the intimate association of individual organisms with one another, beginning with their dwelling together, almost, if not quite, in organic union or continuity, in complete harmony, giving each other mutual assistance, and culminating with those whose relations are those of active strife, each exacting from the other to the utmost every possible advantage. Many other workers turned their attention to the details of the disordered lives provoked by the presence of intruding organisms, but dealt in the main with the life history of the intruders and their methods of attack. Ward cultivated a broader view, and put most prominently before him the general relationships of the two organisms concerned, the question of mutual advantage, or the assistance in nutrition that each supplied to the other, gradually passing on to the advantage of one alone, with possible detriment to the other; the gradual subordination of the life of the one to that of the other; the extent to which such interaction can go till it comes to appear as disease; the further development assuming the character of parasitism. Thus in a series of his works he showed the incoming of symbiosis, and the passage thence to parasitism, through intermediate stages, one of which was first demonstrated by him and given the name of metabiosis.

He investigated many of these ultimately pathological phenomena, tracing the stages of fungal action, and showing how an organism at first harmless can be made to assume the pathogenic habit. In the last years of his life he occupied himself with the still more recondite problems of immunity and infection.

Such was the dominating line of research which he followed. Incidentally it led him to study many subordinate problems, as their solution seemed necessary for the elucidation of points in his larger inquiries. His writings show consequently the tracing out of many life histories, examination of the details of growth of many intruders, the investigation of the mechanism by which in particular cases definite work is done; they deal also with the conditions affecting the relationships of the organisms with which he was at the moment concerned, and with methods to determine how to help or to hinder the processes involved. Incidentally he took up taxonomic problems among the more lowly plants, when the absence or incompleteness of classification obscured advance in some important direction. Here, too, he opened a door to an altogether new field of inquiry, by suggesting that species may differ physiologically, while apparently identical in point of structure.

His early work was anatomical. At the Jodrell Laboratory at Kew he carried out some researches into the structure and development of the embryo sac, a study he pursued later at Würzburg under the direction of Sachs. Anatomy, however, did not claim him long, for he was soon engaged, as we have seen, in the investigation of the leaf disease of the coffee plant in Ceylon, the research which revealed to him his special bent, and which first brought out the thoroughness which always characterised his way in his later years.

The coffee disease proved to be due to one of the Uredinous fungi, and to be, under the conditions in the island, ineradicable. Ward not only identified it, but traced out its life history and its method of infection.

Three other important papers were incident to this Ceylon visit, dealing with two fungi, *Meliola* and *Asterina*, and a new epiphyllous lichen. In these researches he showed all the care and technical skill that characterised his later work, but they were more particularly concerned with the life history of the organisms, and had not much general bearing on what became his special line of inquiry. The paper on the coffee disease led to his acquaintance with De Bary, with whom he formed a friendship that lasted till the latter's death.

When Ward left Ceylon he had acquired a reputation that led to his subsequent career. It was not, however, as a fungologist that he wished to rank, and in his later researches he used his familiarity with fungal structure and growth as subsidiary to the greater problems of health and disease, and to the inter-relations of organisms whose lives are very intimately associated.

As a first step to the elucidation of some of these, he turned his thoughts to the physiological action of the fungi, their mode of perforation of the tissues of their hosts, and the histological details of their life in the interior of the latter. The series of his papers so originated included the infection of the potato plant by *Phytophthora infestans*, of the tissues of *Lilium candidum* by a species of Botrytis, and of the roots of the Leguminosæ by the organism known as *Bacillus radicicola*, to which the production of the characteristic tubercles is due.

It was in connection with this work that Ward discovered in the fungal hyphæ the secretion of a cytase resembling that which was detected in 1890, as we have seen by Brown and Morris in the grain of the barley during germination. He showed the conditions under which the enzyme is formed, the details of its secretion, its granular character during its formation, together with the method of its action. This was published in 1888, two years before Brown and Morris made their observations known. Though occurring in two organisms of such different character and systematic position the process of secretion shows remarkable similarity in the two cases.

The infection of the root of the Leguminous plant was shown to be the actual penetration of an amœboid particle into the root hair, and its subsequent growth along its length till the tissue of the root is reached and invaded. Ward subsequently traced out the development of the intruder up to the formation of the tubercle.

This work was remarkable for the suggestion of symbiosis instead of parasitism as the active factor in the fixation of atmospheric nitrogen which Hellriegel and Wilfarth had shown to be associated with the green plant after the infection is established. To this research we have already alluded elsewhere.

The work on the lily disease went beyond the investigation of the life history of the Botrytis and the discovery of the cytase. Ward in this paper first put forward his view that saprophytism is in some cases only a stage on the way to parasitism; that an organism that has been content to live upon decaying organic matter, may, in the absence of the latter, be educated to attack

living as well as dead tissue, and so to pass from the lower to the higher predatory position. He suggested that parasites may be obligatory or facultative.

In all these works we can see his leading idea guiding him in the details of his more evidently anatomical work, complete and well-balanced as the latter always was.

The complex subject of symbiotic fermentation attracted Ward's attention in 1887, overlapping the researches to which we have just alluded. This was a new departure both from the side of fungal association and of fermentative activity. The plant which occupied his attention in the first instance was the so-called "ginger-beer plant" of the East of England, where it is used to prepare a well-known beverage. The plant as obtained is a jelly-like aggregation of fungoid - looking matter, and unlike any alcohol-producing material so far investigated. Ward analysed it and studied all its components, the research taking up several years of his time at Cooper's Hill. The jelly-like lumps proved to be composed of two essential constituents, a yeast and a bacterium living together symbiotically, and carrying on a joint fermentation. Ward found both to be capable of setting up such an action, but the products of the two separately were quite different from those produced by the complex organism. The yeast was different from the common yeast of brewing, in that it produced comparatively little alcohol.

Ward suggested that while the products formed were useful to the bacterium their removal was necessary to the yeast. So that he elucidated a theory of symbiotic fermentation, though he did not prove completely the truth of his hypothesis.

Not only did he isolate the two constituents from the jelly, but after cultivating them both separately he was able to reconstitute the organism from his cultures.

The plant was by no means a pure admixture of the two; many species of both bacteria and yeast were found to contaminate it. Ward examined each of these separately and investigated their power of fermentation, before pronouncing upon their utility.

Another organism of the same kind was investigated by him in collaboration with the present writer in 1899. This, which was sent from Kew, proved to be similar in composition, and to show another example of symbiosis, though the constituents were different from those of the ginger-beer plant, both morphologically and physiologically.

The intricacy of the relations between fungus and host fascinated

Ward, and he investigated many phases of them. He examined the series of events that transform a saprophyte into a facultative parasite; certain filamentous saprophytes coming into relation with a living plant find themselves able to penetrate its tissues, perhaps by the stomata, perhaps by an accidental wound. Boring into the interior they excrete a poison in advance of the hypha, which kills the tissue in front of it, enabling it to exercise its saprophytic powers. By slow degrees this preliminary poisoning is gradually abandoned by the intruder, and the latter comes to attack the living cell directly. The saprophyte has now become a parasite.

A further more intricate relationship is seen when two organisms are co-operating, one preparing the way for the action of the other, a process which Ward demonstrated in several instances. To this condition, neither symbiosis nor parasitism, he gave the name *Metabiosis*. The discovery of this relationship was an important contribution to the knowledge of the life of organisms, where a successful existence depends upon the close association of several forms. In this line of investigation he was a pioneer.

Out of all this work on parasitism and kindred relationships came Ward's great generalisation as to the meaning of disease. He held the view that it is " the outcome of a want of balance in the struggle for existence." The generalisation was perhaps hasty, as his investigations had only touched one point, viz. the disturbance of the balance due to the invasion of one organism by another. But so far as it went he was able to justify it even then by experiment, and it proved the starting-point of further researches of a deeper significance, dealing with the questions of infection and immunity, and susceptibility to disease. Here he drew attention to the similarity between his problems and the question of the prepotency of pollen, which had been observed long before by Darwin.

Another point of great interest to which Ward gave assiduous care was the question of the existence of a so-called *Mycoplasm*. An idea was promulgated by Frank in 1890, that the curious symbiotic relationship between the invading organism and the roots of the Leguminosæ extended much farther than a community of living cells, that there existed in the cells an intimate mixture of the protoplasm of intruder and host, so that a new form of living substance was, or had been, developed, neither phanerogamic nor fungal, but a combination of both. To this new substance Frank gave the name " Mycoplasm."

In 1897 Eriksson applied this theory to the relations between cereal grasses and *Puccinia graminis*. The outbreaks of rust he said are often so sudden and so inexplicable on any theory of spore-infection that a deeper cause must exist. This deeper cause he thought he had found in the existence of a mycoplasm in a cereal that once had been infected with the rust. Whether or no the rust became discrete, or whether the cereal component of the mycoplasm kept it in check he held to be a question of conditions; if these remained unfavourable there was no evident presence of the fungus, but the latter was always potentially present and ready to manifest itself if the conditions of inhibition were removed.

Ward was always ready to consider critically any hypothesis, even if at the outset it might seem improbable. He passed no hasty judgment on Eriksson's views, but set himself to make a careful investigation of the early appearance of the fungus and a thorough study of the details of infection. By very skilful histological research he was able to trace the entrance of the fungal hyphæ, and to explain completely the appearances on which Eriksson based his opinion, showing that by using proper methods the infection can always be traced to a germinating uredospore. He showed that the appearances of mixed protoplasms were caused by peculiarities in cutting the entering hyphæ—that the "mycoplasm" was only ordinary cell protoplasm with fragments of the fungal filaments mechanically entangled in it.

Ward's latest piece of physiological work, on which, indeed, he was engaged till he was laid aside by his last illness, was an investigation into the processes of infection whereby the rusts attack the cereal and other grasses. He studied to this end the large genus Bromus, cultivating more than 200 species and varieties, and testing the power of each to resist infection. At the outset he looked for some anatomical or histological correspondence between the grass and the infecting spore, whereby some species could be easily infected, while into others neither spore nor resulting hypha could enter. After much labour he found no such correspondence to exist—infection is not a mere physical process. In many cases the entry of the fungus could take place without its leading to the devastating action which we associate with infection. The anatomical hypothesis was, therefore, necessarily abandoned, and Ward decided that some internal factor or factors in the plant determine it. This was a conclusion of vast importance—perhaps one of the greatest he ever formed. Behind it is hidden the question of *immunity*, and with this an

approximation to the relation of disease to the animal body. Closely related comes the existence of toxins and anti-toxins, those subtile agents which affect the resistance of protoplasm to disease, aiding or hindering it in the conflict between itself and some obscure intruding influence, undiscoverable by the aid of histological appliances.

Ward began a series of investigations on these problems, starting with the questions of the susceptibility of different species to the same infecting influences. He made some headway, showing how differences of constitution could be shown to exist in forms which were anatomically identical, and how these differences were marked as similar differences existing between species that were anatomically quite distinct. So he reached the idea of "physiological species," a further great generalisation which he was unhappily unable to pursue.

In the course of his work in this field he found that the conditions of the fungus and the host which enable infection to be brought about could be modified. Here he was on the line possibly of a curative measure; but he did not get so far. He was able to show, on the other hand, that a fungus can be gradually adapted to attack a grass at first immune to it. The specialism of both fungus and host appears to be capable of modification, but the cause and the method remain still obscure. Such were the grave and important problems to which he was devoting his powers when the close of his life unhappily drew near.

It may well be imagined that to so energetic a worker and so thorough an investigator as Ward, many problems arose and demanded solution during the progress of these important researches. We have seen how in the early days the question of enzyme action came to him while he was studying the parasitism of fungi. He investigated the life history and action of several of these organisms to see how far enzymes play a part in their activities. Allusion may be made to *Stereum*, which causes a species of dry rot in certain timber, to *Onygena*, which is similarly destructive of horn and hide. Hence he devised methods of cultivating various fungi *in vitro*, and investigating the conditions which influenced their different methods of reproduction. In many cases he cultivated his fungi by sowing a single spore in a flask of nutrient material.

Allusion may be made also to the masterly research on the bacteria of the Thames water, which he carried out in conjunction with Frankland while he was at Cooper's Hill. In the course of

this he reached the important conclusion that sunlight, particularly the violet and ultra-violet rays, is deleterious to bacterial life.

This discovery led him to some extended observations on the spores of Anthrax, and the microbe of typhoid fever. Interesting as these were, however, they lie somewhat outside our present purpose.

It is easy to believe, however, that Ward attained a position of authority on many scientific or hygienic questions outside his more strictly botanical sphere.

CHAPTER LXII

RESEARCH—*continued*

The Progress of Agriculture

WHILE research was thus making progress in the Universities and other educational institutions, and in private hands, experiments on a very large scale were being continued at Rothamstead on many very important agricultural questions; some of them, it is true, were of almost purely chemical character, but many offered features of interest to the botanist and vegetable physiologist.

Lawes and Gilbert, assisted sometimes by other collaborators, had grappled with several problems, of which the most important was the source of the nitrogen of vegetation, and in three masterly memoirs had shown in the early sixties that it is not supplied to green plants directly by the air.

During the years that had elapsed the work at Rothamstead had become much more completely organised, and series of experiments intended to extend over many years had been started and maintained. The most striking of these were devoted to the study of a range of questions touching the nature of the nutriment supplied to the plant by the soil. The old humus theory had said that the earth presented the plant with everything it needs, and it has only to absorb it. Liebig had proved this erroneous, so far at any rate as carbon is concerned; but he held that the matter of nutriment is a question of the minerals which the plant contains in its ash, so that the main object of a fertiliser or manure is to supply some deficiency in this class of constituents of the soil. Liebig continued to attribute the supply of nitrogen to the plant to the direct intake from the air.

Lawes and Gilbert took a different view, and held that the fertility of a soil depends upon the amount and condition of the combined nitrogen it contains, and that the object of manuring is to provide an appropriate supply. They investigated these points by cultivating definite plots of ground under constant conditions of manuring for many years in succession. In each series of experiments, which were made with most of the ordinary agricultural crops, one plot was left unmanured, one given the

ordinary farmer's sheet anchor, animal dung, and others were supplied with manures of different composition, the effect of which was the subject of the experiment. Among these some received various mixtures of the purely ash constituents; some were supplied with nitrogenous compounds, salts of nitric acid, or compounds of ammonia; while others again had mixtures of both classes of fertilisers. So an almost endless series of experiments began, and for more than fifty years in succession each plot received its definite supply on the lines that had been laid down at the outset. At each successive harvest samples were taken for analysis from every plot, and the results of the long-continued treatment were duly tabulated. The samples are permanently preserved in the Laboratory at Rothamstead.

The accumulation of such a mass of material was of immense value from the point of view of the practical farmer, as well as that of the vegetable physiologist. The latter was perhaps in danger of regretting that the accumulation of statistics became so vast; up to the end of the century not far short of 50,000 samples having been bottled and stored away.

It is clear that with each succeeding year the difficulties of interpretation became greater and much interesting scientific information became buried. Still conclusions of great importance from the point of view of the nutrition of the plant were reached during these years with their laborious work. The results went far beyond the limits of the original proposals; the researches enabled accurate information to be afforded as to the capacity of a crop to obtain its nitrogen from the natural sources, to appropriate from the soil its mineral constituents. It became possible to compute the relative values for cropping purposes of several different nitrogenous compounds. Incidentally, the inquiries led up to larger questions of nutrition and other metabolic phenomena.

Certain œcological problems of great interest arose from time to time, a certain series of experiments in particular dealt with the question of the struggle amongst plants of the Leguminosæ and others of the Gramineæ, when a mixed herbage containing members of both families was supplied with different manures. The influence of variation of the mineral constituents supplied in the soil was found to be very far-reaching, and at the same time it was seen that the relative preponderance of the several forms was largely under control.

About the commencement of the period which is now under

discussion, another research of great importance was undertaken by another observer at Rothamstead, who though not so prominent as Lawes and Gilbert in the agricultural world, did, perhaps, more brilliant work than either of them in vegetable physiology. Robert Warington was born in 1838, and at the age of twenty-one became an unpaid assistant to Lawes. He was attached mainly to the study of chemistry, to which he had devoted much time during his youth. After a year he went to carry out research work at South Kensington under Frankland, and thence went to the Agricultural College at Cirencester, where he acted for some years as assistant to Professor Church. Agricultural chemistry was not unnaturally the branch that most attracted him, and he was particularly interested in the Rothamstead researches, in which for a short time he had been engaged. With the sanction of Mr. Lawes he projected the publication of a work upon the institution and the experiments going on there, and was for some years engaged in putting it into shape. But after he had spent some three years on the project it was found that it could not be successfully completed, owing to opposition on the part of Gilbert, and the book consequently never saw the light. Unfortunately, the incident proved the cause of strained relations between the two, which were not entirely remedied in their later time.

Warington left Cirencester in 1867, and went to take up a post as chemist in Lawes' Manure and Acid works at Millwall, where he stayed till 1876. At this juncture another problem involving nitrogen was coming to the front—the formation and fate of nitrates in the soil, and Warington determined to investigate it, removing his residence to Harpenden to be near Rothamstead. He did a good deal of preliminary chemical work there, examining the methods of estimating both carbon and nitrogen.

In 1877 he set himself to work definitely on his problem, which presented itself to him as a search for the formation of nitrates in the earth, their antecedents, and the agencies by which the transformation is effected. The work was made additionally interesting from the fact that many continental chemists were attacking it at the same time, and questions of priority seemed likely to arise.

Warington was soon led to the conception that the problem was not in the main chemical, but that bacterial agency was involved. In his first series of experiments, begun in 1877 and published in 1879, he found that a solution of ammonium chloride, containing also the other mineral constituents required by green plants,

would not form any compounds of nitric or nitrous acid, unless the germs present in ordinary soil were allowed access to it, and unless an excess of a salifiable base such as calcium carbonate was present. Under these latter conditions nitrification took place after a variable period of incubation. The experiments succeeded best in darkness, and at a temperature below 40° C. In successful experiments again the products were not uniform; sometimes nitrous acid, sometimes nitric acid, and occasionally both were produced. The reason for this discrepancy he left undetermined, saying he had not ascertained the conditions leading to the several results. He seemed to have regarded the various external factors as playing an important part among these conditions; but he held them in some measure, at any rate, to depend upon the state of the germ or ferment in the soil employed.

In his next paper, which appeared in 1884, he was chiefly engaged with experiments on the character and behaviour of the microbe. He started with his old observation of the variation of the nature of the products, and the explanation of it which he was at first inclined to favour, and showed that subsequent experiments had led him to the view that the character of the organism was the determining factor, and that the influence of the external conditions was at any rate subordinate. He said: "It is indeed possible to have two similar solutions under identical external conditions, in one of which only nitrites, and in the other only nitrates are being produced; the difference being determined by the character of the organisms with which the respective solutions have been seeded." After giving further proofs of nitrification being due to an organism, and claiming that the idea was completely established, he went on to describe the distribution of the organism in the soil, and to show the depth to which it penetrates.

In the course of his memoir of this date, Warington said that in 1879-80 he was able to prepare a culture solution (of course containing microbes) which was incapable of oxidising ammonia, but was energetic in converting nitrites into nitrates. He held at the time the opinion that this course of action indicated merely a phase in the life history of the nitrifying organism.

In a further paper, published in 1891, he gave special attention to the conditions under which nitrites are formed, and those under which they are oxidised to or replaced by nitrates. He started with the observation that in natural soil in ordinary cases, the nitrites are due to the action of reducing bacteria working in a deficient supply of oxygen, but that this is not the case when a

strong solution of some ammonium salt is treated with a small quantity of soil. Oxidation then takes place, first nitrites, and later nitrates, being formed. Then reverting to the experiments that led him to the conclusion in 1884 already quoted, he described how he had taken one of the cultures that contained only nitrites (in which he had said the nitrifying agent had "assumed the nitrous character"), and continued its cultivation for three years, keeping it pure. It never formed nitrates under any conditions.

He again interpreted his result by ascribing the behaviour to a peculiar condition of attenuation of the organism. At the same time a suspicion began to make itself felt that possibly it might be a question of two organisms rather than one. Further cultures followed, in which he was successful in isolating the organism by which nitrites are formed, but though he sought diligently and with great care, the search for a second form was unsuccessful.

Warington's work was thus unfortunately left incomplete. The new microbe was found a little later by Winogradski.

Warington must, however, retain the credit of proving that the action is bacterial, and not purely chemical, and of isolating the first known of the two microbes. Professor and Mrs. Frankland confirmed his discovery later in the same year.

This was the last agricultural research in which he was engaged. He left Rothamstead in 1891, and resided many years at Harpenden, surviving both Lawes and Gilbert.

While Warington was engaged in this aspect of the great nitrogen question, another phase of it occupied Lawes and Gilbert for three years. In 1886 Hellriegel and Wilfarth published the results of a series of experiments that had occupied them for several years. They demonstrated in their investigations that plants of the Natural Order Leguminosæ are capable of availing themselves of the free nitrogen of the air so long as their growth is associated with the presence of peculiar nodular outgrowths on their roots, and they affirmed that there is some correspondence between the luxuriance of these tubercles and the amount of nitrogen absorbed.

This statement brought up the old controversy as to the atmosphere as a source of nitrogen in an acute form. Lawes and Gilbert were attracted at once by the new problems. In the course of their former investigation they had determined that "leguminous crops assimilate from some source so very much more nitrogen than gramineous ones under ostensibly equal circum-

stances of supply of combined nitrogen, that it is desirable that the evidence of further experiments should be obtained." They accordingly set themselves to investigate the matter on the lines that Hellriegel and Wilfarth had indicated. They began their experiments in 1887, and worked at the problem for three years, ultimately being able to confirm the German investigators in every particular.

The result elucidated several points of much obscurity that had been noticed by previous observers. Lawes and Gilbert themselves had found in 1883 that under crops of sanfoin the nitrogen of the soil increases in spite of the removal of large amounts in the crops, a very remarkable and apparently inexplicable phenomenon first observed by Dehérain in France.

Hellriegel and Wilfarth did not carry the matter farther than the association of the tubercular growth with the fixation of the nitrogen, leaving altogether unexplained the nature of the relationship. The interaction of two organisms of such very different morphological rank appealed very strongly to Marshall Ward, who had already studied questions at first sight somewhat similar. He set himself at once to investigate the interaction of the plants to bring about so striking a result. He first examined the structure of the tubercles, and the mode of infection which led to their development, and soon found that they were not produced in cultures of leguminous plants in sterilised solutions, but could be made to appear with great ease if pieces of chopped nodules were put in contact with their root hairs. The growth was clearly seen to be the result of infection by the second organism, which, normally present in the soil, was taken up from it or from the chopped nodules or the water which had access to them.

He proceeded to study the course of development of the organism after it had reached the green plant. His discoveries were extensive; they showed that infection takes place through the root hair, down which a filamentous growth makes its way as soon as a certain bacterium-like body comes into contact with it. After passing through the root hair it traverses the cortex of the root, and at some point or other causes considerable hypertrophy of the tissue, which becomes recognisable as a young tubercle. In the cells of the latter, after its development, the protoplasm is found to become frothy and vacuolated, simulating the appearance of a plasmodium. Corpuscles eventually fill the cells, being budded off from the filamentous growth of the bacillus in great profusion. On the decay of the tubercles later, some of these

corpuscles are discharged into the soil, while the rest are dissolved or disappear in the cells.

Ward came to the conclusion that the relation between the two is one of symbiosis.

The last contribution of the century to the subject was made by Dr. Maria Dawson, who published a very complete investigation of the structure and life history of the so-called bacillus in 1899 and 1900. Confirming in the main the much earlier observations of Marshall Ward, she showed that the hypha-like structures which penetrate to the nodule are strands of rodlets lying side by side in a homogeneous matrix, which contains neither cellulose nor chitin, and which is probably zooglœal in nature.

Germs, or bacteroids, are budded off from them, which are of various shapes, often simulating the appearance of a V, an X, or a Y. She left it undecided whether these forms are the results of branching or of the reunion of two or more individuals. In some cases in addition to these she observed certain mobile forms.

A very complete investigation of the process of infection led her to the conclusion that there is only one organism capable of forming nodules on the roots of leguminous plants, and working symbiotically with them. In opposition to Hellriegel and Wilfarth she attributed the difficulty of inoculating one genus with bacteroids from another to special physiological peculiarities of the several hosts and to the organisms of infection being specific in each case. Here we have a suggestion of the same kind as was put forward by Marshall Ward about the same time as to physiological differences which may be an indication of a specific distinction altogether apart from anything morphological.

The results thus detailed as to the great problems of nitrogen utilisation dwarf all other research into agricultural botany in England during these years. Attention may, however, be called to the work of Acton on the changes in the proteins which accompany the ripening of wheat in the stack.

Apart from Rothamstead and such work as was more or less directly instigated by the researches there, investigations into the problems of agriculture were not pursued with any diligence. Such as were carried out elsewhere touched rather chemical and physiological than botanical questions. At the Rothamstead station Lawes and Gilbert continued for the rest of the century the experiments on continuous cultures under constant conditions, to which we have referred. Apart from these, their work, though extremely valuable, did not boast of great originality. All

through the history of the station it can be seen that they were largely critical examiners of research that had first been seen elsewhere. In many cases they did great service by supplying confirmation of results which were unexpected, and were, on their first pronouncement, received with scepticism. They continued, however, to carry out their plans as they formed them from time to time, till the end of the century, when in honoured age they both passed away with little interval between them. Sir John Lawes died in 1900; Sir Henry Gilbert in 1901.

The experiments on continuous culture attracted very great attention all over the agricultural world. As Sir Henry Gilbert was associated most closely with them he was often called upon to give courses of lectures upon them not only in England, but in parts of the New World. On account of the reputation they brought to him he was appointed Sibthorpian Professor of Rural Economy at Oxford in 1884 and in 1887, the tenure of the Chair being limited to six years after its severance from the Sherardian Professorship on the resignation of Lawson.

In 1889 Sir John Lawes, conscious of his increasing years and apprehensive of failing powers, determined to make arrangements for the continuation of the Rothamstead experiments, so that his own decease should not interfere with the career of usefulness on which the station had been launched. He accordingly set aside a sum of £100,000 for its endowment, and leased the laboratory and experimental fields to a Board of three Trustees. He arranged that after that year (1889) the management of the station should pass into the hands of a Committee of nine persons, of which he was one; with four to be nominated by the Royal Society, one by the Chemical Society, one by the Linnean Society, two by the Royal Agricultural Society. He stipulated that his place should be taken at his death by the then owner of Rothamstead. The appointment of new Trustees when required was vested in the Royal Society, and due arrangements were made for the nomination from time to time of new members of the Committee of Management.

The end of the century, however, found both Lawes and Gilbert still at Rothamstead.

Warington was then living in retirement at Harpenden. During the progress of his work he was made a Fellow of the Royal Society in 1886. After he had left the station he was appointed in 1894 Sibthorpian Professor at Oxford. He died in 1907.

There is no doubt that the work at Rothamstead, and the influ-

ence it exerted among the landlords of England, gave considerable impetus to the scientific study of agriculture. Local agricultural societies were formed in almost all the counties on the lines of the Royal Agricultural Society, and agricultural education became much more systematised. Agricultural Colleges had existed for many years at Cirencester and at Downton. During these last decades of the century others were founded at Wye, in Kent, at Reading, at Bangor, and at Newcastle, and experimental stations were established in connection with them.

A new departure was taken in 1894 at Woburn, where an experimental fruit farm was founded by the Duke of Bedford, to take the place in horticulture that Rothamstead had filled in relation to agriculture.

It is not the purpose of the author to trace in his book the progress of botanical science in England further than the closing years of the nineteenth century. The literature of the next one will prove that alike in the herbarium, the laboratory, and the field England is giving and has given birth to workers who are fully as worthy of a niche in the temple of Fame as any of those whose labours and achievements this book is now the record.

CHRONOLOGICAL TABLE

(*The numbers in brackets after the items indicate the pages in the text where the subjects are discussed.*)

1516. First publication of the *Grete Herball*. (18).
1525. Publication of Banckes's Herbal. (19).
1526. Publication of the best-known edition of the *Grete Herball*. (18).
1529. William Turner graduated at Cambridge. (20).
Birth of Lyte. (32).
1531. Turner made Fellow of Pembroke College, Cambridge. (20).
1538. Publication of Turner's *Libellus de re Herbaria novus*. (23).
Birth of L'Obel. (29).
1544. Publication of Turner's *Historia de Naturis Herbarum Scholiis et Notis vallata* at Cologne. (23).
1545. Birth of Gerard. (34).
1548. Publication of Turner's *Names of Herbes*. (23).
1550. Ascham's *Lyttel Herbal* (19) and Thomas Hill's *Profytable Arte of Gardening* published. (27).
1551. First part of Turner's *History of Plants* (a new *Herball*) published in London. (23).
1562. Second part published at Cologne. (23).
Publication of Bulleyn's *Herbal*. (26).
1564. Third part of Turner's *Herball* published at Cologne. (23).
1567. Birth of Parkinson. (48).
Publication of Maplet's *Green Forest*. (63).
1568. Death of Turner. (22).
Reprinting of his *Herball* with the third part. (23).
1569. Gerard made Freeman of the Company of Barber-Surgeons. (34).
1570. Publication of L'Obel's *Stirpium Adversaria*. (29).
1574. Hill's *Arte of Grafting and Planting of Trees* published. (27).
1576. Publication of L'Obel's *Observationes*. (30).
1578. Publication of Lyte's translation of Dodoens. (31).
1583. Publication of Cæsalpino's System. (68).
1588. Gerard's Proposals to Lord Burghley for construction of Botanic Garden, Cambridge. (175).
1589. Death of Bulleyn. (27).
1596. Publication of Gerard's *Catalogus*. (37).
1597. Production of Gerard's *Herball*. (38).
1599. Appearance of second edition of Gerard's *Catalogus*. (37).
Birth of Bobart the elder. (56).
1600. Platt's *Garden of Eden* published. (48).
1605. Publication of second part of L'Obel's *Adversaria* and his *Animadversationes*. (30).
1606. Publication of Ram's *Little Dodoen*. (33).
1607. Death of Lyte. (32).
Gerard made Master of the Company of Barber-Surgeons. (34).
1612. Probable date of the death of Gerard. (37).
1616. Death of L'Obel. (29).
Birth of Merret. (60).
1619. Birth of How. (58).

1620. Publication of the *Prodromus* of Kaspar Bauhin. (45).
Birth of Morison. (98).
1621. Foundation of the Oxford Botanic Garden by the Earl of Danby. (54).
1623. Publication of K. Bauhin's *Pinax*. (29).
1628. Birth of John Ray. (71).
1629. Publication of Johnson's *Iter in Agrum Cantianum* (44) and of Parkinson's *Paradisus in Sole*. (49).
1630. Birth of Sir Andrew Balfour. (111).
1632. Publication of Johnson's *Ericetum Hampstedianum*. (44).
Opening of the Botanic Garden, Oxford. (54).
1633. Publication of Johnson's edition of Gerard's *Herball*. (45).
The Apothecaries' Company organised their "Herborisings." (44).
1634. Publication of Johnson's *Mercurius Botanicus*. (45).
1635. Birth of Robert Hooke. (120).
1636. Second edition of Johnson's *Gerard* published. (45).
1638. Probable date of death of Tradescant. (57).
1640. Publication of Parkinson's *Theatre of Plants*. (51).
1641. Johnson's *Mercurius Bot. Pars Altera* published. (45).
Heaton's manuscript on the Irish names of plants. (191).
Births of Nehemiah Grew (123), and of Sir R. Sibbald. (111).
1642. Birth of Plukenet. (92).
1644. Death of Johnson. (44).
1648. Publication of Bobart's *Catalogue of the Oxford Botanic Garden*. (56).
1650. Publication of J. Bauhin's *Historia*. (69).
Morison made steward of the Botanic Garden at Blois. (98).
Death of Parkinson. (48).
Publication of How's *Phytologia*. (58).
1652. Culpepper's *Herbal* published. (63.)
1655. Publication by How of L'Obel's *Illustrationes*. (59).
1656. Death of How. (58).
1658. Publication of the second edition of Bobart's *Catalogue*. (56).
Ray's first botanical tour. (74).
1659. Lovell's *Herbal* published. (63).
Birth of W. Sherard. (162). Birth of Samuel Dale. (94).
1660. Improvement of the microscope by Hooke. (121).
Ray's *Catalogus Plantarum circa Cantabrigiam nascentium*, with a sketch of his proposals for classification. (72).
Return of Morison to England and appointment as royal professor of botany to Charles II. (99).
Birth of Hans Sloane. (153).
1661. Ray's second botanical tour. (74).
1662. Hooke appointed curator of experiments to the Royal Society. (120).
Posthumous publication of Jung's *Isagoge Phytoscopica*. (69).
Ray's third botanical tour. (74).
Ray's departure from Cambridge. (72).
1663. Publication of Ray's first appendix to the Cambridge Catalogue. (75).
Ray's tour with Willughby and other friends through the South of Europe. (75).
1664. Robert Turner's *Herbal* published. (63).
Publication of Merret's *Physiological Experiments* (116), and of Evelyn's *Sylva*. (110).
1665. Publication of second edition of Lovell's *Herbal* (63), and of Hooke's *Micrographia*. (120).
1666. Ray contributed his "Tables" to Bishop Wilkins's *Real or Universal Character*. (75).
Publication of Merret's *Pinax*. (60).
1667. Ray's fourth botanical tour. (75).

1667. Edinburgh Botanic Garden founded by Sibbald and Balfour. (112).
1668. Ray's fifth botanical tour. (75).
1669. Ray's physiological work carried out. (76). His translation into Latin of Bishop Wilkins's *Real or Universal Character* finished. (75).
Morison's views on System published in his *Hortus Blesensis*. (99).
Morison made professor of botany at Oxford. (101).
1670. Ray's *Catalogue of English Plants* published. (77).
Grew's *Anatomy of Plants Begun* read to the Royal Society. (125).
1671. Ray's sixth botanical tour. (77).
Malpighi's MS. read to the Royal Society. (126).
Birth of Stephen Hales. (198).
1672. Deaths of Bishop Wilkins (73) and Francis Willughby. (74).
Publication of Morison's *Plantarum Umbelliferarum*. (103).
Grew made curator in anatomy of plants to the Royal Society. (126).
Grew's *Anatomy*, Part ii., read to the Royal Society. (126).
1673. Marriage of Ray and publication of his *Catalogus Stirpium in exteris regionibus*. (78).
Chelsea Physic Garden founded by the Apothecaries' Company. (150).
1674. Morison's publication of Boccone's treatise. (101).
Grew's *Anatomy*, Part iii., read to Royal Society in April, and Malpighi's second part communicated in August. (126).
1676. Sutherland made intendant to the Edinburgh Botanic Garden. (113).
Birth of Threlkeld. (191).
1677. Removal of the Edinburgh garden to grounds of Trinity Hospital.(113.)
Grew and Hooke made secretaries of the Royal Society. (120).
Ray removed into Essex (78), and published second edition of his *Catalogue of British Plants*. (77).
1678. Publication of the last edition of Lyte's *Herbal*. (33).
1679. Ray's removal to Black Notley. (78).
1680. Death of Jacob Bobart the elder. (56).
Publication of Morison's system of classification. (103).
1682. Ray's *Methodus Plantarum nova*, published. (79).
Publication of Grew's work in one volume. (127).
Suggestion of sexuality in plants by Grew and Millington. (141).
1683. Death of Morison. (86). Succession of Bobart the younger as *Horti præfectus*, Oxford. (109).
Birth of Professor Alston. (186).
Publication of Sutherland's *Hortus Medicus Edinburgensis*. (113).
1684. Sibbald's *Prodromus Historiæ Naturalis Scotiæ* published. (112).
1685. Publication of Ray's second appendix to the Cambridge Catalogue.(75).
1686. Publication of first volume of Ray's *Historia Plantarum Generalis*. (86).
1687. Sloane's Jamaica explorations. (153).
Birth of Dillenius. (164).
1688. Publication of Ray's *Fasciculus* (77). and of the second volume of the *Historia*. (86).
1690. Ray's controversy with Rivinus. (82).
Publication of Ray's *Synopsis Methodica Stirpium Britannicarum*. (88).
1691. Commencement of Plukenet's *Phytographia*. (92).
Birth of Philip Miller. (156).
1693. Sloane made secretary to the Royal Society. (154).
Dale's *Pharmacologia* published. (94).
Doody put in charge of the Chelsea Garden. (152).
1694. Publication of Peechey's *Herbal*. (63).
Ray's *Sylloge Stirpium Europæarum* published. (89).
Publication at Tübingen of the work of Camerarius on the sexuality of plants. (144).
1695. Sutherland made professor of botany at Edinburgh. (113).

1695. Publication of Ray's local floras in Camden's *Britannia*. (89).
Abortive attempt to found a botanic garden at Cambridge. (175).
Publication by Llhwyd of papers on fossil plants. (110).
Death of Merret. (60).
1696. Controversy between Ray and Tournefort. (83).
Publication of second edition of Ray's *Synopsis* (89), of Plukenet's *Almagestum Botanicum* (92), of second edition of Sibbald's *Prodromus* (112), and of Sloane's *Prodromus of Jamaica Plants*. (154).
1698. Ray's final sketch of a system of classification drawn up. (83).
1699. Morison's *History* completed by Jacob Bobart the younger. (109).
Birth of John Martyn. (176).
1700. Plukenet's *Almagesti Botanici Mantissa* published. (92).
Bobart's experiments on sexuality in *Lychnis*. (144).
1702. W. Sherard made consul at Smyrna. (163).
Publication of Petiver's *Gazophylacii naturæ et artis, Decades decem*. (152).
1703. Morland's theory of fertilisation propounded to the Royal Society. (144).
Death of Hooke. (120).
Publication of the final form of Ray's *Methodus*. (83).
1704. Completion of Ray's *Historia*. (86).
Construction of the first botanic garden at Glasgow; John Marshall put in charge of the Botanical teaching. (188).
1705. Death of John Ray. (95).
Sutherland resigned the chair of botany at Edinburgh. (114).
Publication of Plukenet's *Amaltheum Botanicum*. (92).
Death of Plukenet. (92).
1706. Death of Doody. (152).
Petiver appointed demonstrator of plants at Chelsea Garden. (152).
C. Preston made professor of botany at Edinburgh. (185).
1710. Ray's *Methodus* reprinted at Amsterdam. (83).
1711. Salmon's *Herbal* published. (64).
G. Preston succeeded C. Preston in the chair of botany at Edinburgh. (185).
Lectureship in botany established at Trinity College, Dublin; Nicholson made lecturer. (192).
1712. Death of Nehemiah Grew. (123).
Sloane purchased the Manor of Chelsea. (155).
Nicholson's *Methodus* published. (192).
1713. Publication of Petiver's *Catalogue of Ray's English Herbal*. (92).
1715. Birth of Sir W. Watson. (219).
1716. Consul Sherard's return to England. (163).
Alston made superintendent of Botanic Garden, Edinburgh. (186).
Publication of Bradley's *Succulent Plants*. (175).
1717. Bradley's experiments on the fertilisation of tulips. (193).
1718. Death of Petiver. (92).
1719. Resignation and subsequent death of Bobart the younger. (109).
Death of Marshall at Glasgow; chair of botany combined with that of anatomy; Thomas Brisbane made professor. (189).
Publication of Dillenius' *Giessen Catalogue*. (165).
Bradley's experiments on hybridisation. (194).
1720. Publication of translation of Tournefort's *Catalogue* by J. Martyn. (177).
Blair's *Botanic Essays* published. (196).
Birth of Patrick Browne. (286).
1721. Dillenius brought to England by Consul Sherard. (163).
1722. Death of Sibbald. (112).
Chelsea Garden transferred by Sloane to the Apothecaries' Company. (155).

1722. Philip Miller made gardener. (156).
1724. Isaac Rand appointed *præfectus horti* or Director of Chelsea Physic Garden. (156).
Publication of Miller's *Gardener's Dictionary*. (156).
Chair of botany established at Cambridge; Bradley made first professor. (175).
Third edition of Ray's *Synopsis* published by Dillenius. (167).
1725. John Martyn began to lecture in London and was deputed to take Bradley's work at Cambridge. (177).
Birth of Hope. (276).
1727. Publication of John Martyn's *Methodus Plantarum circa Cantabrigiam nascentium*. (178).
Hales' *Vegetable Staticks* published. (199).
Threlkeld's *Synopsis Stirpium Hibernicarum* published. (191).
1728. Death of Consul Sherard. (164).
Death of Threlkeld. (191).
Endowment of the Sherardian professorship of botany at Oxford. (163).
1729. Publication of Micheli's *Nova Plantarum Genera*. (171).
1730. Birth of Pulteney. (240).
Birth of Ingen-Housz. (293).
1731. Publication of the second edition of Miller's *Gardener's Dictionary*. (156).
Foundation of the Dublin Society. (286).
1732. Birth of Hudson. (271).
Death of Bradley. (176).
Publication of Miller's *Gardener's Kalendar* (157), the *Hortus Elthamensis* of Dillenius (167), and John Martyn's *Historia Plantarum rariorum*. (180).
1733. John Martyn made professor of botany at Cambridge. (177).
Hales' *Haemostatiks* published. (199).
1734. Dillenius made Sherardian professor of botany at Oxford. (164).
1735. Birth of Thomas Martyn. (229).
Birth of Lightfoot. (279).
1736. Visit of Linnæus to England. (169).
1737. Birth of James Dickson. (281).
Blackstone's *Fasciculus Plantarum circa Harefield sponte nascentium* published. (219).
1738. Resignation of G. Preston at Edinburgh; Alston made professor of botany. (186).
1739. Death of Rand. (159).
Death of Samuel Dale. (94).
1741. Publication of *Historia Muscorum* by Dillenius. (169).
Birth of Withering. (258).
1742. Death of Brisbane; succession of Robert Hamilton to the Glasgow chair; extension of the Glasgow garden. (189).
1743. Birth of Sir Joseph Banks. (247).
1744. Publication of Wilson's translation of Ray's *Synopsis*. (218).
Cullen settled at Glasgow. (189).
1746. Birth of William Curtis. (273).
Blackstone's *Specimen Botanicum* published. (219).
1747. Death of Dillenius; succession of Humphrey Sibthorp. (172).
John Wilmer made demonstrator of plants at Chelsea. (176).
1749. Death of Professor G. Preston. (186).
Royal Charter granted to the Dublin Society. (286).
1750. Needham's observations on pollen published. (196).
Cullen made professor of medicine at Glasgow; co-operation established between him and Professor Hamilton. (189).

1751. Publication of Hill's *History of Plants*. (222).
1752. Death of Sir Hans Sloane. (155).
Francis Skene made professor of civil and natural history at Marischal College, Aberdeen. (188).
1753. Publication of Alston's *Tirocinium Botanicum Edinburgense*. (187).
1754. Publication of Alston's *Essay and Observations*, containing his opposition to the sexuality of plants. (197).
Birth of Thomas Wheeler. (274).
1755. Miller's *Figures of plants* published. (157).
1756. Removal of Cullen from Glasgow to Edinburgh; resignation of Professor R. Hamilton; succession of Black. (190).
1757. Resignation of Black; succession of Thomas Hamilton. (190).
1758. Publication of Hill's *Hortus Kewensis*. (267).
1759. Birth of Thomas Andrew Knight (295) and of Sir James Smith. (253).
Appointment of Aiton to take charge of Princess Augusta's gardens at Kew. (265).
Publication of Stillingfleet's translation of Linnæus' tracts. (223).
Miller's *Gardener's Dictionary* arranged on the Linnean system. (157).
Cambridge Botanic Garden founded by Dr. Walker. (182).
1760. Linnean system adopted in Great Britain. (184).
Publication of Hill's *Flora Britannica*. (222).
Death of Alston. (188). Hope elected to chair of botany in Edinburgh. (223).
Lyons lectured at Oxford at invitation of Banks. (248).
Solander settled in England. (223).
1761. Resignation of Cambridge chair by John Martyn. (178). Succession of Thomas Martyn. (223).
Death of Stephen Hales. (199).
1762. Completion of Cambridge Botanic Garden. (182).
Publication of Hudson's *Flora Anglica*. (223).
1763. Publication of Lyons' *Fasciculus*, and of Martyn's *Plantæ Cantabrigienses*. (181).
Thomas Martyn's first course of lectures at Cambridge. (232).
1764. Birth of the elder Don. (279).
1765. Kew and Richmond Gardens fused by Act of Parliament. (265).
Hudson made *præfectus horti* at Chelsea. (159).
1766. Banks's expedition to Newfoundland. (248).
1768. Death of John Martyn. (178).
Banks's embarkation with Captain Cook. (248).
1770. Thomas Martyn made curator of Cambridge Botanic Garden. (183).
Philip Miller resigned post of gardener at Chelsea. (272). Forsyth succeeded him. (273).
1771. Death of Philip Miller. (159).
Martyn's *Catalogue of the Cambridge Garden* published. (231).
Resignation of Hudson as director of Chelsea Garden. (272). Alchorne made honorary director. (273).
Priestley discovered exhalation of oxygen by plants. (292).
1772. Banks's expedition to Iceland. (249).
Banks made director of Kew. (250).
1773. William Curtis made director of Chelsea Garden. (273).
Birth of Robert Brown. (311).
Edward Hill appointed lecturer in botany at Trinity College, Dublin. (285).
1774. Thomas Martyn ceased residence in Cambridge. (232).
1775. First publication of Ingen-Housz in Transactions of Royal Society. (293).

1776. Removal of Edinburgh Botanic Garden to Leith Walk. (277).
Publication of Withering's *Botanical Arrangement.* (259).
1777. Publication of Curtis's *Flora Londinensis.* (273).
Curtis resigned directorship of Chelsea; Thomas Wheeler appointed. (274).
Lightfoot's *Flora Scotica* published. (279).
1778. Sir Joseph Banks made president of the Royal Society. (250).
1779. Publication of Ingen-Housz's *Experiments on Vegetables.* (293).
1781. Pulteney's *General View of the Writings of Linnæus* published. (240).
Nucleus of the Herbarium of Trinity College, Dublin, formed by Brown's collection of West Indian plants. (286).
Death of Professor Thomas Hamilton; succession of William Hamilton to the Glasgow chair. (283).
1782. Death of Solander. (249).
1783. Birth of Loudon. (379).
Hortus Kewensis published by Aiton. (251).
The Linnean Collection acquired by Sir J. E. Smith. (253).
1784. John Sibthorp made professor of botany at Oxford. (242).
Forsyth resigned position as gardener at Chelsea; Fairbairn succeeded. (275).
Aiton made chief of Kew Gardens. (266).
1785. Publication of Relhan's *Flora of Cambridgeshire* and Thomas Martyn's *Letters of Rousseau.* (233).
Birth of Sir W. J. Hooker. (388).
E. Hill made professor of botany in Trinity College, Dublin. (286).
1786. Publication of Ingen-Housz's *Researches on Respiration* (294); of the appendix to Relhan's *Flora of Cambridgeshire* (233); of Thomas Martyn's *Language of Botany* (236), and of the second edition of Withering's *Botanical Arrangement.* (259).
Death of Professor Hope; Rutherford made professor of botany at Edinburgh. (279).
1787. Curtis started the *Botanical Magazine.* (273).
1788. Foundation of the Linnean Society. (254).
James Beattie made professor at Marischal College, Aberdeen. (285).
Publication of the second appendix to Relhan's *Flora.* (233).
Sir J. E. Smith discovered the sensitivity of the stamens of Berberis. (305).
1789. Publication of *Reliquæ Rudbeckianæ* by Smith. (254).
Genera Plantarum published by De Jussieu in France. (331).
1790. Sir J. E. Smith and Sowerby began the issue of the *English Botany.* (254).
Death of Professor William Hamilton; succession of Jeffray to the Glasgow chair. (284).
Francis Bauer invited to Kew by Sir Joseph Banks. (251).
Publication of Pulteney's *History of Botany* (240) and of vol. i. of Woodville's *Medical Botany.* (263).
Foundation of Don's Botanic Garden at Forfar. (280).
1791. *Pathology of Trees* published by Forsyth. (274).
1792. Don made superintendent of Edinburgh Botanic Garden. (280).
Flora Rustica begun by Martyn. (237).
Publication of vol. ii. of Woodville's *Medical Botany* (263), of the third vol. of Withering's *Botanical Arrangement.* (259).
1793. Publication of the third appendix to Relhan's *Flora* (233), and of vol. iii. of Woodville's *Medical Botany.* (263).
The professorship of botany at Cambridge made a regius professorship. (238).
Deaths of W. Hudson (272) and the elder Aiton. (267).

1794. Publication of the supplement to Woodville's *Medical Botany* (263) and of Sibthorp's *Flora Oxfordiensis*. (243).
Publication of Wade's *Catalogus Systematicus Plantarum ind. in Com. Dublinensi*. (287).
1795. Publication of Dickson's *Catalogus Plantarum Cryptogamicarum Britanniæ*. (281).
Foundation of Glasnevin Botanic Garden, Dublin, by Dublin Society. (287).
Birth of Daubeny. (422).
1796. Death of John Sibthorp. (243).
Martyn's last course of lectures at Cambridge. (237).
Birth of Henslow. (366).
Publication of Bauer's drawings. (260).
1797. Ingen-Housz published his *Essay on the Food of Plants*. (293).
Dr. Wade made professor of botany to the Dublin Society instead of lecturer. (287).
1799. Deaths of Ingen-Housz (293), Withering (259), and Curtis (274).
Resignation of Professor Edward Hill of Trinity College, Dublin. (289).
Births of John Lindley (338) and Wilson the bryologist. (445).
Botany at Glasgow put under Thomas Brown. (284).
1800. Births of Charles Darwin (454) and George Bentham. (492).
Publication of Knight's papers on the ascent of sap and on diaheliotropism. (297).
Election of Dr. R. Scott to the chair of botany at Trinity College, Dublin. (289)
1801. Death of Pulteney. (240).
Flinders' expedition to Australasia. (311).
Underwood's *Catalogue* of the plants in the Glasnevin Garden published. (288).
1802. Kew Gardens altered by the closure of Love Lane. (265).
Publication of the second edition of Relhan's *Flora* (233); of Forsyth's *Management of Trees* (274); and of Underwood's *Catalogue* of the Arboretum, etc., at Glasnevin (288).
1803. Birth of M. J. Berkeley. (445).
Publication of Knight's work on the ascent and descent of the sap. (296).
Foundation of the Horticultural Society. (357).
Birth of H. C. Watson. (514).
1804. Thomas Martyn made rector of Pertenhall. (238).
Mackay made assistant to Professor Scott at Dublin. (289).
Publication of Don's *Herbarium Britannicum*. (280).
1805. Discovery of Buxbaumia by Hooker. (388).
Robert Brown made librarian to the Linnean Society. (312).
Publication of Knight's work on geotropism and centrifugal force. (300).
1806. Publication of vol. i. of Sibthorp's *Flora Græca* by Sir J. E. Smith. (256).
Foundation of Ball's Bridge Botanic Garden by Trinity College, Dublin. Mackay made curator. (289).
1807. Publication of Martyn's edition of Miller's *Gardener's Dictionary* (236) and of Smith's *Introduction to Physiological and Systematic Botany*. (256).
1808. Birth of J. Hutton Balfour (429) and of C. C. Babington. (371).
Resignation of Thomas Brown at Glasgow; Botany again under Professor Jeffray. (284).
1809. Royal Charter granted to the Horticultural Society. (357).
Knight removed to Downton. (295). Published his work on hydroropism. (302).

1809. Publication of Brown's work on the mosses, the Proteaceæ (314), and the Apocynaceæ, and Asclepiadaceæ. (315).
Resignation by Professor Scott of the chair of botany at Trinity College, Dublin. (289). Succession of William Allman. (290).
1810. Death of Dryander; Robert Brown made librarian to Sir Joseph Banks. (249).
Jos. Sabine made secretary to the Royal Horticultural Society. (358).
Publication of Robert Brown's *Prodromus Novæ Hollandiæ.* (313).
Death of Professor Beattie at Aberdeen; William Knight made lecturer on botany at Marischal College. (285).
1811. Birth of Harvey the algologist. (437). Birth of Thwaites. (447).
1812. Publication of Knight's work on negative heliotropism. (302).
Birth of Binney. (386).
1813. J. E. Smith proposed as Martyn's successor as reader at Cambridge. (256).
Publication of vol. ii. of the *Flora Græca* (256) and of the second edition of Aiton's *Hortus Kewensis.* (270).
Wells's observations on natural selection. (453).
1814. Smith and Sowerby's *English Botany* completed. (255).
Birth of Lawes. (426).
1815. First sketch of De Candolle's system published in Switzerland. (336).
Botany at Glasgow put under Robert Graham. (393).
1816. Publication of Robert Brown's memoir on the Compositæ (317) and of W. J. Hooker's work on the British Jungermanniæ. (389).
Birth of W. C. Williamson. (518).
Knight resigned the charge of botany at Marischal College, Aberdeen. (285).
1817. Birth of J. H. Gilbert. (427).
Birth of J. D. Hooker. (467).
1818. Death of Jeffray at Glasgow; succession of Graham; Regius professorship constituted. (284).
Royal Charter granted to the Botanic Society of Glasgow. (430).
Dr. J. E. Smith proposed as deputy professor of botany at Cambridge. (256).
1819. Cambridge Philosophical Society formed. (366).
Death of Rutherford (279). Edinburgh chair declined by Robert Brown; Graham appointed. (318).
Opening of Sandyford Botanic Garden, Glasgow. (284).
1820. Death of Sir Joseph Banks. (251).
W. J. Hooker made regius professor of botany at Glasgow, after the chair had been declined by Robert Brown. (390).
Resignation of Thomas Wheeler; his son, J. L. Wheeler, made professor of botany at Chelsea. (275).
Dublin Society assumed the prefix "Royal." (290).
Publication of third edition of Relhan's *Flora of Cambridge.* (233).
1821. Foundation of the Garden of the Royal Horticultural Society at Chiswick. (357).
De Jussieu's system first taught at Chelsea. (332).
J. S. Henslow proposed as Martyn's deputy at Cambridge. (367).
Henslow's tour in Anglesea. (367).
Edinburgh Botanic Garden removed to Inverleith Row. (394).
Publication of Lindley's edition of Cattley's *Collectanea Botanica.* (338).
Gray's *Natural Arrangements of British Plants* published. (339).
1822. Lindley appointed garden secretary to the Royal Horticultural Society. (339).
David Don succeeded Robert Brown as librarian to the Linnean Society. (364).

1822. Death of James Dickson. (282).
Publication of Loudon's *Encyclopædia of Gardening*. (379).
Some suggestions on natural selection made by Herbert. (453).

1823. Birth of Alfred Russel Wallace. (457).
William Knight made professor of natural philosophy at Marischal College, Aberdeen, with charge of botanical teaching. (285).

1824. Publication of Sir J. E. Smith's *English Flora*, vols. i. and ii. (257).

1825. Death of Professor Thomas Martyn; succession of J. S. Henslow to the Cambridge chair. (366).
Death of Professor Wade at Dublin. (287). Succession of Litton. (396).
Birth of T. H. Huxley. (527).
Publication of Mackay's *Catalogue of the Indigenous Plants of Ireland*. (289).
Bentham's journey to the Pyrenees. (493).
Publication of vol. iii. of Smith's *English Flora* (257), D. Don's *Prodromus Floræ Nepalensis* (365), Loudon's *Encyclopædia of Agriculture* (379), and Robert Brown's work on the ovule. (323).
Robert Brown founded the group Gymnospermia. (323).

1826. Grant published work on the descent of species. (453).
Publication of Robert Brown's memoirs on the Cruciferæ and other orders. (317).

1827. Foundation of a joint medical school at Aberdeen; William Knight made lecturer on botany. (395).
Burnett and Mayo localised the sensitivity of Mimosa. (377).
Sir Joseph Banks's herbarium transferred to the British Museum; Botanical department established with Robert Brown as keeper. (319).
Nicol devised the method of cutting sections of rocks. (385).

1828. Death of Sir J. E. Smith. (254).
Publication of vol. iv. of Smith's *English Flora*. (257).

1829. Publication of Lindley's *Synopsis of the British Flora*. (339).
Chair of botany established at University College, University of London; Lindley made first professor. (345).
Chelsea Physic Garden thrown open to students. (361).
Publication of Loudon's *Encyclopædia of Plants*. (379).

1830. Publication of Francis Bauer's illustrations of orchids with Lindleys' text. (325).
Lindley and Bentham joint secretaries to the Royal Horticultural Society. (339).
Publication of Lindley's first proposals on classification. (340).
Improvements made on large scale at Glasnevin Botanic Garden. (396).

1831. Foundation of the New Botanic Garden, Cambridge. (369).
Voyage of the *Beagle* undertaken. (454). Matthew wrote on origin of species. (453).
Lindley and Hutton began publication of the *Fossil Flora*. (386).
Publication of Robert Brown's memoir on the Orchidaceæ, containing account of his discovery of the nucleus in the vegetable cell. (327).
Foundation of chair of botany at King's College, London; Burnett made first professor. (364).
Birth of C. B. Clarke. (491).
Johnson began second edition of Smith and Sowerby's *English Botany*. (380).

1832. Enlargement of Botanic Gardens of Trinity College, Dublin. (397).
Publication of third edition of Woodville's *Medical Botany* (263), Witham's memoir on Lepidodendron (385), and Bentham's *Labiatarum Genera*. (494).

1833. Lindley's second proposals on classification. (343).
Publication of Witham's *Internal Structure of Fossil Vegetables* (385) and of Williamson's first memoir. (518).
Coulter made keeper of the herbarium, Trinity College, Dublin. (397).
Inauguration of the Chiswick flower shows by the Royal Horticultural Society. (414).
1834. Percival Wright born. (523).
Neven made superintendent of Botanic Garden, Glasnevin. (396).
Curtis discovered the mechanism of the closure of the leaf of Dionæa. (377).
Brewster investigated the absorption spectrum of chlorophyll. (377).
Daubeny succeeded Williams as Sherardian professor at Oxford. (422).
Publication of Robert Brown's paper on the "Embryogeny of the Coniferæ." (324).
1835. Burnett made professor of botany at Chelsea (364). On his death this year Lindley succeeded him at Chelsea with title *præfectus horti* (345). At King's College D. Don made professor. (364).
1836. Foundation of Botanic Society of Edinburgh. (395).
Return of the *Beagle*. (454).
Completion of Smith's *English Flora* by Hooker and Berkeley. (258).
Publication of Mackay's *Flora Hibernica*. (289).
Lindley's third proposals on classification. (346).
Alexander Dickson born. (522).
Wardian cases introduced by Nathaniel Bagshaw Ward at Chelsea. (511).
1837. Completion of Lindley and Hutton's *Fossil Flora*. (386).
Publication of Herbert's memoir on the Amaryllideæ. (380).
Agricultural experiments instituted at Rothamstead by Lawes. (428).
Hartweg sent on expedition to Mexico by the Royal Horticultural Society. (413).
Darwin first began to investigate permanence of species. (455).
1838. Death of Thomas Andrew Knight. (295).
Birth of Warington. (617).
Linnean system abandoned at Chelsea. (363).
Lindley's fourth proposals on classification. (346).
Publication of Lindley's *Sertum Orchidaceum*, and *Flora Medica* (347); Loudon's *Arboretum et Fruticetum* (379); Dickie's *Flora Aberdonensis*, (395).
Hooker and Bauer began publication of the *Genera Filicum*. (411).
D. Moore made superintendent of Glasnevin Botanic Garden. (396).
1839. Lindley's fifth proposals on classification. (346).
Henslow's removal from Cambridge. (370).
Dissolution of the joint medical school at Aberdeen; resignation of Wm. Knight; Shier appointed lecturer at Marischal College, and Dickie at King's College, Aberdeen. (435).
Foundation of the Botanic Garden at Regent's Park, London, by the Royal Botanic Society. (415).
Dr. J. D. Hooker appointed naturalist to the expedition of the *Erebus* and *Terror* to the Antarctic. (468).
Bentham contributed monograph on the *Ericaceæ* to De Candolle's *Prodromus*. (494).
1840. Resignation of W. T. Aiton (402). Kew Gardens put under charge of the Office of Woods and Forests. (357).
Daubeny made Sibthorpian professor of rural economy, Oxford. (422).
Publication of Lindley's *Theory of Horticulture*, and his completion of Sibthorp's *Flora Græca*. (347).
1841. *Gardener's Chronicle* commenced by Lindley. (347).

1841 1840. W. J. Hooker appointed director of Kew Gardens. (401).
Bentham resigned co-secretaryship of the Royal Horticultural Society; Lindley made vice-secretary. (348).

1841. Death of David Don. (362). Forbes made professor of botany at King's College, London. (418).
J. Hutton Balfour made professor of botany at Glasgow. (429).
McGillivray appointed professor of civil and natural history at Marischal College, Aberdeen. (435).
Kew Gardens thrown open to the public every week-day afternoon. (401).

1842. First sketch of the *Origin of Species* made by Darwin. (455).
Glasgow Botanic Garden transferred to Kelvinside. (430).
Publication of Draper's work on the rays of light used in photosynthesis. (377).
H. C. Watson's *Flora of the Azores* published. (514).
Fortune sent on expedition to China by Royal Horticultural Society. (413).

1843. Extension of Kew Gardens. (402).
Deaths of Coulter (397) and Loudon. (380)
Association of Lawes and Gilbert in the work of the Rothamstead Experiment Station. (427).
Resignation of the Dublin chair by Professor W. Allman. (442).
Robert Brown's work on the Embryogeny of the Coniferæ appeared in the *Ann. des. Sc. Nat.* (324).
Inauguration of the Regent's Park flower shows by the Royal Botanic Society. (416).
Birth of Henry Trimen. (515).
Publication of Babington's *British Botany*. (509).

1844. Darwin's first sketch of the *Origin of Species* shown to Dr. J. D. Hooker. (455).
The *London Catalogue* drawn up by Watson. (514).
Publication of the first vol. of Hooker's *Flora of the Antarctic Islands*. (469).
Publication of Binney's *Fossil Trees*. (386).
G. J. Allman appointed professor of botany in Trinity College, Dublin (442), and Professor W. H. Harvey made curator of the herbarium. (439).

1845. Death of Graham at Edinburgh (395). Appointment of J. Hutton Balfour to succeed him (431), and of Walker Arnott to be professor at Glasgow. (431).
Daubeny commenced the experimental study of agriculture at Oxford. (423).
The Deer Park added to Kew Gardens and the Arboretum laid out. (402).
Death of Anderson of Chelsea Gardens. (417).
Lindley's sixth proposals on classification. (352).
Publication of Lindley's *Vegetable Kingdom*. (352).

1846. Death of Professor W. Allman. (397). 1843 acc. [illegible]
New botanic garden at Cambridge laid out by Henslow. (370).
Royal kitchen garden added to Kew Gardens. (402).
Appointment of Fortune as gardener at Chelsea. (417).
Publication of Harvey's *Phycologia Britannica* begun. (439).
Completion of second edition of Smith and Sowerby's *Botany*. (380).

1847. Death of Thomas Wheeler. (275).
Establishment of museum at Kew; Alexander Smith made curator. (406).
The Indian explorations of Dr. J. D. Hooker first undertaken. (470).

1847. Publication of Part II. of Hooker's *Flora Antarctica*. (453).
1848. Death of Professor Litton at Dublin; succession of Harvey. (469).
Extension of Botanic Gardens of Trinity College, Dublin. (443).
1848. Resignation of Fortune at Chelsea; Thomas Moore appointed gardener. (417).
1849. Dickie resigned lectureship at Aberdeen on appointment to chair of natural history at Queen's College, Belfast. (435).
Christie made lecturer in botany at King's College, Aberdeen. (436).
1850. Kew Gardens put under charge of the Board of Works and Public Buildings. (402).
Publication of Lindley and Paxton's *Flower Garden*. (347).
1851. Wyville Thomson succeeded Christie at King's College, Aberdeen. (436).
Completion of Harvey's *Phycologia Britannica*. (440).
W. C. Williamson made professor of natural history at Owen's College, Manchester. (518).
1852. Death of McGillivray. (435). Succession of Nicol; Wyville Thomson made lecturer in botany at Marischal College, Aberdeen. (436).
Death of Lemann, leaving herbarium to Cambridge University. (495).
Fielding Herbarium left to University of Oxford. (559).
1853. Wyville Thomson succeeded at King's College, Aberdeen, by Crombie Brown. (436).
Agricultural Laboratory erected at Rothamstead. (427).
Establishment of the Museum of Irish Industry and Government School of Science at Dublin. (444).
Abolition of office of *præfectus horti* at Chelsea; resignation of Lindley. (418).
Publication of Hooker's *Flora Novæ Zealandiæ*. (477).
1854. Forbes succeeded as professor of botany at King's College, London, by Henfrey. (418).
Foundation of the Kew herbarium on the presentation of Bloom field's plants. (406).
Erection of the Succulent House, Kew. (485).
Publication of Hooker's *Flora Indica* (477) and *Himalayan Journals*. (471).
Bentham settled at Kew, and presented his herbarium to the gardens. (406, 495).
1855. Resignation of G. J. Allman at Dublin (443). Succession of W. H. Harvey. (440).
Dr. J. D. Hooker made assistant director of Kew Gardens. (410).
1856. Lindsay's *History of British Lichens* published. (434).
1857. Collaboration of Sir J. D. Hooker and Mr. Bentham in the preparation of the *Genera Plantarum*. (472).
1858. Publication of the *Origin of Species* at the Linnean Society. (458).
Death of Robert Brown. (320).
J. J. Bennett made keeper of the botanical department, British Museum. (513).
Publication of Bentham's *Handbook of the British Flora*. (497).
Commencement of Harvey's *Phycologia Australica*. (441).
1859. Death of Henfry; Bentley made professor of botany in King's College, London. (418).
Publication of J. D. Hooker's *Flora Tasmaniæ*. (472).
Completion of Watson's *Cybele Britannica*. (514).
1860. Erection of the Temperate House, Kew. (407).
Dickie made professor of botany at Aberdeen. (436).
Dr. Hooker's Syrian tour undertaken. (473).
1861. Resignation of Lindley. Daniel Oliver made professor of botany at University College, London. (490).

1861. Death of J. S. Henslow; succession of Babington to the Cambridge chair. (508).
Publication of Bentham's *Flora of Hong Kong*. (496).
1862. Death of Mackay at Dublin. (443).
Publication of J. D. Hooker's *Essay on the Distribution of Arctic Plants* (473), and of Darwin's *Fertilisation of Orchids*. (465).
The herbarium of Chelsea Gardens presented to the British Museum. (512).
1863. Completion of Harvey's *Phycologia Australica*. (442).
Commencement of Bentham's *Flora Australiensis*. (496).
1864. Completion of W. J. Hooker's *Species Filicum*. (410).
1865. Death of Sir W. J. Hooker. (411). Appointment of Dr. J. D. Hooker as director of Kew Gardens. (473).
Royal College of Science, Dublin, established. (444).
Publication of Lindley and Moore's *Treasury of Botany*. (417).
Death of Lindley. (353).
1866. Purchase of Sir W. J. Hooker's herbarium by government and its incorporation into the Kew herbarium. (486).
Death of W. H. Harvey (441). Succession of Alexander Dickson. (522).
Publication of Binney's work on *Lepidodendron*. (520).
1867. Death of Daubeny. (425).
Alexander Dickson made professor of botany in the Royal College of Science, Dublin. (523).
1868. Publication of Hooker's *Synopsis Filicum* (410), and Darwin's *Variation in Plants and Animals under Domestication*. (465).
Death of Walker Arnott; succession of A. Dickson to the Glasgow chair. (431).
Appointment of Lawson to the Oxford chairs. (506).
Death of N. Bagshaw Ward. (512).
Appointment of Percival Wright to succeed Dickson at Trinity College, Dublin (522), and of Wyville Thomson to the Royal College of Science, Dublin. (523).
1869. Publication of Babington's *British Rubi* (508), Trimen and Dyer's *Flora of Middlesex* (515), and Master's *Teratology*. (517).
1870. Thiselton Dyer made professor of botany at the Royal College of Science, Dublin. (529).
Commencement of Williamson's series of memoirs on the plants of the Coal Measures. (520).
1871. Dr. J. D. Hooker's African expedition. (474).
Publication of the last volume of the *Flora of Tropical Africa*. (478).
1872. Thiselton Dyer made professor of botany to the Royal Horticultural Society; succession of McNab at Dublin. (523).
Huxley's lectures at South Kensington undertaken. (528).
1873. Completion of the Pinetum at Kew Gardens. (484).
Thiselton Dyer's first course of lectures at South Kensington. (531).
1875. Death of J. J. Bennett; succession of Carruthers as keeper of the Botanical Department, Natural History Museum. (514).
Thiselton Dyer appointed assistant director at Kew Gardens. (484).
1876. Opening of the Jodrell Laboratory at Kew. (490).
Resignation of Dickie at Aberdeen; succession of J. W. H. Trail. (436).
Appointment of S. H. Vines as lecturer in botany at Christ's College, Cambridge. (537).
1877. Decision of commission to separate the Sherardian and Sibthorpian chairs at Oxford. (507).

1877. Transference of control of Glasnevin Botanic Garden to the Royal College of Science, Dublin. (524).
Hooker's American tour. (474).
1878. Completion of Bentham's *Flora Australiensis*. (496).
1879. Resignation of J. Hutton Balfour at Edinburgh. (431). Appointment of Alexander Dickson to the chair (432), and of I. Bayley Balfour to succeed him at Glasgow. (572).
Appointment of R. Irwyn Lynch to curatorship of Botanic Garden, Cambridge. (554).
Warington's first memoir on nitrification in the soil. (617).
1880. Death of D. Moore at Dublin. (524).
Professor McNab made scientific superintendent and referee at Glasnevin Gardens. (524).
Publication of Darwin's *Power of Movement in Plants*. (465).
1881. Death of H. C. Watson. (514).
First allotment of a laboratory to Vines at Cambridge. (538).
1882. Death of Charles Darwin. (454).
Removal of Francis Darwin to Cambridge. (545).
Retirement of D. Oliver from the chair at University College, London; D. H. Scott made assistant-professor. (562).
Hillhouse made first professor of botany at Mason's College, Birmingham. (539).
1883. Victoria University constituted (562). Marshall Ward made lecturer at Manchester under Williamson (553), and Harold Wager at Leeds under Miall. (563).
Resignation of Lawson at Oxford. (556).
Establishment of readership in botany at Cambridge; Vines made reader. (546).
1884. Death of George Bentham. (498).
Appointment of Bayley Balfour to the Sherardian (556), and J. H. Gilbert to the Sibthorpian chairs at Oxford. (560).
Extension of the Botanical Laboratory at Cambridge. (546).
Warington's second paper on nitrification in the soil. (618).
1885. Resignation of Sir J. D. Hooker. (475). Appointment of Thiselton Dyer to be Director of Kew Gardens. (490).
Appointment of Bower to be Regius Professor of botany in Glasgow. (574).
Removal of Marshall Ward to Cooper's Hill (553), and of Scott to South Kensington. (561).
Commencement of the publication of the *Flora of India*. (471).
1886. Publication of Vine's *Physiology of Plants*. (546).
1887. Death of Alexander Dickson at Edinburgh, and succession of Bayley Balfour. (556).
Resignation of Bentley at King's College, London, and succession of Groves. (561).
Annals of Botany established. (547).
Extension of the laboratory at Cambridge. (547).
Botanical department established at University College, Liverpool, under Harvey-Gibson. (562).
Reconstitution of the Royal Horticultural Society. (571).
1888. Election of Vines to the Sherardian chair at Oxford. (548).
F. Darwin made reader in botany at Cambridge. (549).
F. W. Oliver appointed Quain professor of botany at University College, London. (561).
1889. Death of Professor McNab; succession of Dr. T. Johnson to the chair at the Royal College of Science. (577).
M. C. Potter made first professor of botany in Newcastle College of Science, University of Durham. (564).

1889. The agricultural station at Rothamstead put under a committee of management and amply endowed by Sir John Lawes. (622).
1890. Resignation of the keepership of Kew herbarium by D. Oliver; succession of J. G. Baker. (491).
Further extension of laboratories at Cambridge. (549).
1891. F. Darwin made deputy professor of botany at Cambridge. (549).
Warington's final paper on nitrification in the soil. (619).
Retirement of Warington from Rothamstead. (622).
1892. Publication of first volume of the *Index Kewensis*. (475).
New botanical laboratory constructed at Liverpool. (563).
D. H. Scott made honorary keeper of the Jodrell Laboratory, Kew. (561).
J. Bretland Farmer made assistant professor of botany at South Kensington. (561).
Resignation of Williamson of the chair at Manchester; succession of F. E. Weiss. (562).
Retirement of M. C. Cooke from the Cryptogamic Department, Kew; succession of G. Massee. (567).
1893. Death of Bentley. (510).
Retirement of Groves and succession of Bottomley to the professorship of botany at King's College, London. (561).
1894. Warington elected Sibthorpian professor of rural economy at Oxford. (560).
Harvey-Gibson made professor of botany in University College, Liverpool. (563).
1895. Publication of last volume of the *Index Kewensis*. (475).
Death of Babington (550). Marshall Ward elected professor of botany at Cambridge. (552).
Death of W. C. Williamson. (520).
Resignation of Carruthers ; succession of Murray as keeper of the Botanical Department at the Natural History Museum. (562).
1896. Death of Lawson. (508). Death of Trimen. (516).
1897. Completion of Hooker's *Flora of India*. (475).
1899. Chelsea Garden surrendered by the Apothecaries' Company. (570).
Resignation of J. G. Baker; succession of Hemsley as keeper of the herbarium, Kew. (567).
1900. Death of Sir J. B. Lawes. (622).
Foundation of the Hartley Botanical Laboratories at Liverpool. (563).

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